# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

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**MARCH 1916.**

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# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

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### MARCH 1916.

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## GENERAL PHYSICS.

**267.** *Harmonic Synthesiser.* **D. C. Miller.** (Frank. Inst., J. 181. pp. 51–81, Jan., 1916.)—Gives a full description, with numerous diagrams and photographs, of a 32-element harmonic synthesiser. The machine provides for amplitudes up to 34 cm. for any one of the first six components, the other five amplitudes not exceeding 10 cm. each at the same time. The instrument is based on the well-known pin-and-slot device, and is easily and quickly manipulated. A 10-component curve, for example, can be synthesised in about 5 mins., while the machine can be set for 30 components and the curve drawn in 12 mins. Numerous examples are given of curves drawn by the machine. A. W.

**268.** *Model visibly representing Gas Molecules.* **E. F. Northrup.** (Phys. Rev. 7. p. 148, Jan., 1916. Abstract of paper read before the Am. Phys. Soc., Oct. 30, 1915.)—Physical apparatus for illustrating the main principles of the kinetic theory of gases. Approximately 16,000 1/16th inch steel balls in a cylindrical glass enclosure are maintained in motion in the precise manner in which the molecules of a gas are supposed to move. The apparatus enables us to show: (1) The change of pressure of a gas at constant volume with change of temperature, (2) the change of volume at constant pressure with change of temperature, (3) the viscosity of a gas, (4) Brownian motions in liquids and gases, (5) the relation between the gas pressure and the number of impacts, at a given temperature, per unit time per unit area. A. B. W.

**269.** *Comparison of a Schäffer and Budenberg Pressure-balance with the Open Standard Gauge of the Leiden Physical Laboratory between* 20 *and* 100 *Atmos.* **C. A. Crommelin** and **E. I. Smid.** (K. Akad. Amsterdam, Proc. 18. pp. 472–483, Oct. 30, 1915. Comm. No. 146*a* from the Phys. Lab., Leiden.)—The results of this comparison, made through the intermediary of closed hydrogen manometers, are as follows:—The functional section of the pressure-balance is not independent of the pressure, but as the latter increases from 20 atmos. it increases to a maximum at about 70 atmos., and then diminishes more rapidly as far as the comparison was carried; the greatest deviation is 0·0020 cm.$^2$. When the determinations were repeated, the same value was not always found for the functional section, the greatest deviation in this case being about 0·0005. The functional section differs from the geometrical section as given by Schäffer and Budenberg (1 sq. cm.) by about 0·0030 cm.$^2$. Thus the sensitivity of the pressure-balance, namely, 1 in 10,000, greatly exceeds its accuracy, and if the latter is to be raised to the level of the sensitiveness, the theory of the instrument must be developed and means found to obtain constant results with the limits of the sensibility. It is probable that, in order to attain such accuracy, a pressure-balance will always have to be compared, either directly or indirectly, with an open manometer. Pressures measured with a Schäffer and Budenberg pressure-balance which has not been calibrated cannot at present be estimated as more accurate than about 1 in 400, provided that the error in the area of the piston is not larger than 0·1 %. T. H. P.

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**270.** *Distance between Two Parallel Transparent Plates.* **C. Barus.** (Phys. Rev. 7. pp. 79–86, Jan., 1916.)—The method here described makes use of a film grating. Light from a collimator passes through the grating G and then through the glass plate H whose distance from the grating is to be found: the grating has its ruled face towards the glass plate, which is half-silvered. The transmitted light is viewed by a telescope. Three types of interferences, of successive orders of fineness, are obtained. The first involves the colours of thin plates, resolved spectroscopically, while the others depend on diffraction. To measure the thickness of the air-space it is necessary to count the number of fringes between two definite Fraunhofer lines, supposing the grating constants to be known. With the plate H half-silvered, and the grating G left clear, only the fine fringes are seen strongly on transmission. The others appear on reflection at the grating, and may be observed easily in the second order. With the ruled face of the grating half-silvered, the reflected field is largely destroyed; but the transmitted field is now strong, particularly in the second order, for all three sets of fringes. Ives's direct-vision prism grating shows the fine fringes well in the direct beam. The fine fringes may always be found in the principal focal plane of a telescope, but the medium and coarse fringes usually lie in focal planes differing from each other. Thus, by adjusting the eyepiece, it is possible to eliminate any of the interferences, or to show a single set only in the field. The theory of the method is given and the practical details are discussed, examples being given of measurements made at different distances apart of H and G. If 100 fringes can be counted between the D and *b* lines, the method permits of measurements of thicknesses of air films from a fraction of a wave-length of light up to about 1·7 cm. A. W.

**271.** *Disturbance of Elastic After-effect by Elastic Hysteresis.* **H. Jordan.** (Deutsch. Phys. Gesell., Verh. 17. 23. pp. 428–436, Dec. 15, 1915.)—Although there is available a large amount of data concerning elastic hysteresis and particularly elastic after-effects, yet present knowledge of the limits and mutual relations of these two phenomena are not quite settled. The present paper is therefore a contribution to this problem. Previous work receives very adequate attention, and the results of Voigt, Cantone, Warburg, Heuse, and Wiechert are reviewed. Voigt found by experimenting with a large number of rods of different metals that the self-damping of the oscillations of small amplitude, whether produced by bending or torsion, and their dependence on frequency, cannot be explained satisfactorily by internal friction. Cantone traces the self-damping of torsional oscillations made by iron wires exclusively to hysteresis. Statical measurements showed these to be independent of time. The repetition of Cantone's statical experiments with Voigt's bars showed that small bendings bring about results independent of time. Elastic after-effects were next proposed as being the cause of this self-damping of oscillations. The latter is a property exhibited by a body which is almost perfectly elastic, and is shown, after change of form by bending of torsion, as a change in the force necessary to retain the given shape, or as a change in shape if the force be kept constant. By periodic change of force the displacement lags in phase; the displacement regarded as a function of the force gives therefore, as in pure hysteresis, a slip whose form depends on the interval elapsed. In general, the observed change is appreciably greater than the calculated amount. Similar results were afforded by Voigt's experiments. A large number of experiments on the nature of the after-effect under simple conditions have been undertaken. While measurements with Al could be theoretically explained from the standpoint of hysteresis, similar data from iron could not be so explained. The after-effect with limiting force-values, however, runs regularly. An elaborate theoretical investigation is included in the paper, followed by a detailed description of the experiments undertaken. Aluminium, iron, and zinc were first examined under simple conditions, when the least complex behaviour was exhibited by Al and the most by Zn. While the data given by Al were in accordance with theory, iron gave simple after-effects, which, while proportional to the logarithm of the time, were also dependent on other factors. These were next investigated. Several changes of force in cyclical order were made, and while the theoretical results were never obtained, yet the divergence for iron was much greater than for Al. This disturbance was found to be due to hysteresis.

The author regrets not being able to draw general conclusions from his investigations. H. H. Ho.

**272.** *Influence of Temperature and Mechanical Work during the Forging of Wrought Iron and Mild Steel.* **O. Fuchs.** (Zeits. Vereines Deutsch. Ing. 59. pp. 915–918, Nov. 6, 1915.)—The author has carried out a series of experiments to determine the influence exerted by temperature and mechanical work on the properties of iron and mild steel during their forging. The results show that the amount of work necessary to produce a certain amount of deformation in the critical ranges is greater than the amount necessary to produce a similar deformation at temperatures above or below these ranges. Microscopic examination of the materials used showed that the deformation in the critical ranges produced its effect by virtue of the fact that the pressure hindered the formation of the ferrite grains. Brinell hardness tests indicated that the minimum hardness was obtained in the specimens which had been subjected to a compression test at the temperature of the $Ar2$ change. By annealing the crushed specimens the material was restored to its original properties. F. C. A. H. L.

**273.** *Elastic Strength of Metals.* **F. C. Thompson.** (Faraday Soc., Trans. 11. pp. 104–116; Disc., 116–117, Oct., 1915.)—Since a pure metal consists of allotriomorphic crystals, it is reasonable to expect that the surfaces in contact should be sources of weakness, but experience has shown that the crystal boundaries are actually sources of strength. In order to explain this apparently anomalous behaviour the idea of the existence of an amorphous intercrystalline cement has been developed. Since, however, these intercrystalline films are of extreme thinness, certainly beyond the limits of microscopic vision, the hypothesis necessitates the assumption that the strength of the amorphous material is far beyond anything justified by our knowledge of the properties of undercooled liquids. The conception that surface-tension effects are to be observed in the amorphous layers was originally put forward by Quincke and developed by Beilby and others, but the author has developed the theory on novel and definite lines.

When two plates are separated by a film of liquid which wets them, a marked attraction occurs, the intensity of which is $2AT/d$ dynes, where A is the area of the plate wetted by the liquid, T the surface tension of the liquid, and $d$ the thickness of the film. Somewhat similar conditions exist at the crystal boundaries in a metal; two crystals are separated by a film of undercooled liquid, and the pressure, instead of being atmospheric, is derived from the vectorial forces of crystallisation. On this basis the very thinness of the films is the source of their greatest strength, and if for any reason their width is increased the strength of the mass is lowered. The greatly increased strength of a fine-grained metal over that of a coarser one is also explained on the basis of the increased area over which attraction occurs. The relation of stress to strain is probably most accurately represented by the diagram obtained by Robertson and Cook [Abs. 1770 (1913)]. Their diagram differs from those usually obtained in that it shows a marked dip in the curve at the yield-point. On the basis of the author's theory the elastic limit is the stress which just equals the resultant of the interface attractions in the direction of the application of the stress. Further increase in stress draws the crystals apart and results in a permanent set. Actual separation of the crystals is prevented by flow of amorphous material from the more highly compressed areas. During this stage of the test, therefore, every increase of load increases the thickness of the amorphous films; and since the intercrystalline attraction or the resistance of the metal to the stress is inversely proportional to the thickness of the films, every increase of load produces a rapid fall in the resistance to the stress and a period of instability—the yield-point—occurs.

From various considerations the author shows that the elastic limit E is equal to $1{\cdot}5nT/d$, which expresses the attraction as closely as it is possible to do so. Copper, Zn, Sb, Ag, Pb, Sn, Ni, and pure Fe have been examined for mechanical properties, and the size of their grains has been determined by microscopic examination. To investigate the influence of crystal size, the iron was tested after various forms of heat-treatment by means of which the number of crystals per cm. was varied from 690 to 10. The results indicate that in all the metals examined the thickness of the intercrystalline cement is of the same order and approximately equal to $3{\cdot}7 \times 10^{-4}$ cm. The order of the thickness of the cement has also been obtained by means of observations of the electrical conductivity. The electrical resistance of a metal is made up of two factors, the resistance of the crystalline material and the resistance of the intercrystalline cement. It can be represented by the equation $\rho_1 = \rho_2 + nR$, where $\rho_1$ is the resistivity of the sample, $\rho_2$ the resistivity of the crystalline material, $n$ the number of crystals per cm., and R the boundary resistance. By actual observation it was shown that increased grain-size is accompanied by a corresponding decrease in the resistivity. Calculation of the value of $d$ for iron gives an average value of $4{\cdot}7 \times 10^{-4}$, a value which is in close agreement with the one already given above. These values are obviously too high since they would be well within the limits of microscopic vision, but it is shown that the calculations are based on a too high estimate for the surface tension, the real tension being reduced owing to the fact that between two crystals there is a layer of matter in which the molecules are arranged so as to pass by gradual small displacements from the orientation of one crystal to that of the other. It is therefore probable that the thickness of the amorphous film is of the order of $10^{-8}$ cm. F. C. A. H. L.

**274.** *Bending Elasticity of Cast Iron.* **A. Ono.** (Kyushu Univ., Mem. 1. 2. pp. 111–164, 1915. In German.)—According to Bach the relation between the tensile strength $K_z$ and the bending strength $K_b$ of cast iron is given by the equation $K_b = \mu\surd(e/z_0)K_z$, where $e$ is the distance of the outer fibres from the centre line, $z_0$ the distance of the centre of gravity of the section on one side of the centre line from the centre line, and $\mu$ a coefficient depending on the shape of the section. For sections bounded by straight lines this coefficient is approximately equal to 1·2. The author has carried out tensile, compression and bending tests on bars made from the same Japanese cast iron. The results show that the ratio between the bending and tensile strengths is 1·78, while the coefficient $\mu$ in the equation given above is 1·4. On the basis of the figures obtained in the tensile and compression tests the relation between the bending moment and the extension of the outer fibres in tension have been determined graphically. Attention must be drawn to the fact that the residual extensions in the outer fibres in tension were much smaller than those observed in the tensile test. This difference is ascribed to the existence of internal stresses in the I-bar as cast. F. C. A. H. L.

**275.** *Copper and Bronze. Effect of Drawing and Annealing with Special Reference to the extended Tensile Test.* **W. Müller.** (Zeits. Vereines Deutsch. Ing. 59. pp. 933–937, Nov. 13, 1915.)—Experiments have been carried out on copper, bronze, and two samples of magnesium bronze with the object of determining their mechanical properties after various forms of mechanical and heat treatments. The results obtained for the various alloys are so similar that only the copper tests are described as typical of these alloys.

The elastic limit of drawn copper is a rectilinear function of the degree of drawing, but it has not been found possible to raise the elastic limit until it equals the ultimate strength. While the ultimate strength increases very gradually, the yield-point increases rapidly at first and then more slowly as the degree of drawing increases. The contraction decreases in direct linear relationship with the degree of drawing, while the elongation decreases rapidly until the reduction of section in the die reaches about 20 %, after which the decrease is much less rapid. The modulus of elasticity increases with the amount of drawing, the rate of increase showing a decrease at about 60 % contraction. The ratio of the ball hardness to the max. strength attains a vague maximum at about 20 % contraction. This ratio appears to be fairly constant for all metals and is approximately equal to 3. Annealing decreases the strength and hardness and increases the ductility. A max. softening effect occurs in the temperature region situated between 180° and 330° C.; the temperature at which softening begins depending upon the amount of drawing to which the wire has been subjected, being lower as the amount of drawing is increased. At the same time the temperature interval over which the softening takes place is increased with the amount of drawing. The completely softened material has mechanical properties that depend upon the degree of drawing, in the direction that harder-drawn material is always stronger than a material which has been subjected to less drawing. A model has been prepared to show the relationship between the decrease in strength, the degree of drawing and the temperature of annealing. The ordinary method of representing a tensile test by means of an autographic load-extension diagram, while good enough for all practical purposes, still leaves something to be desired from the theoretical point of view. A perfect representation of the mechanism of the tensile test can only be obtained on the basis of the effective stress, *i.e.* the stress acting on the smallest diam. of the test specimen after the applied load has acted long enough for the stretching to be complete so that a state of equilibrium has been attained. If a diagram is then plotted with the effective stress and the reduction of area as co-ordinates, an exhaustive analysis of the tensile test is obtained. This has been carried out for copper wires of various diameters in the drawn and annealed conditions. The results show that when an annealed material is drawn down in stages it passes through the whole series of intermediate states from soft to hard. It is in one of these intermediate stages that alterations of shape can take place most readily, and in the case of copper this state appears to be attained when the reduction of section by drawing lines between 20 and 30 %. The results have been extended by microscopic examination. F. C. A. H. L.

**276.** *The Proportional Limit of Metals.* **A. N. Mitinsky.** (Mech. Eng. 37. pp. 48-49, Jan. 21, 1916. Abstract of paper read before the Am. Inst. Mining Eng., San Francisco, Sept., 1915.)—The theory of elasticity, the science of the strength of materials, and all intelligent engineering designs are based on Hooke's law. Consequently, the proportional limit—the point at which the deformation ceases to be proportional to the load—is a much more important factor than the ultimate strength in engineering design. The more frequent use of the ultimate strength is probably due to the fact that it is easy to determine and to the erroneous notion that the elastic limit is proportional to the ultimate strength. It is a common and great mistake to substitute the yield-point for the proportional limit. These two values have no definite relationship with each other, for it is shown that in a steel properly treated both mechanically and thermally, the proportional limit and the yield-point are very close together, while in a steel of poor quality there may be a great difference between the two values. From a physical point of view the proportional limit is the load at which the shear stresses produced by tension or compression are sufficient to break down the metal. At this point there is a change in the internal structure, Hartmann lines (?) [Lüder lines] appear on the surface of the specimen, and its temperature rises. The resistance of a metal to fatigue depends entirely on its proportional limit, since no amount of repetition of lower stresses can cause any change in the internal structure with consequent injury. It would appear, therefore, that the fatigue test under stresses exceeding the elastic limit could very well be replaced in practice by a determination of the elastic limit. When properly carried out such a determination can be made in about 20 mins., and the Russian railway authorities are now largely introducing the proportional limit into their rail specifications.

Wear of rails and tyres is of two kinds, that due to deformation by crushing and that due to abrasion. The first depends entirely on the value of the proportional limit. Practical experience has failed to establish any relationship between wear and Brinell hardness, ultimate strength, yield-point, elongation, contraction, chemical composition, or the results of the drop test. However, examination of rails and tyres which had given good wearing properties in service showed high proportional limits, while rails which soon showed signs of crushing had low proportional limits. Generally speaking, a steel with medium carbon-content and a fine-grained structure will have a high proportional limit. The only cases in which a high proportional limit does not correspond with a steel of good quality are in steels with a Widmanstätten structure (overheated) or steels with high phosphorus, As, or Mn content. In all these cases brittleness is readily detected by the drop test. The question of wear by abrasion is one which has received little attention, and all that is definitely known about it is that sulphur tends to increase wear from this cause. There appears to be no relation between wear by abrasion and Brinell hardness or ultimate strength. **F. C. A. H. L.**

**277.** *Behaviour of Iron and Steel during Compression Tests.* **H. Monden.** (Stahl und Eisen, 35. p. 1022, Oct. 7, and p. 1052, Oct. 14, 1915. Am. Soc. Mech. Eng., J. 37. p. 721, Dec., 1915. Abstract.)—The results of a series of tests, carried out with the object of determining the effect of variation in the shape of test-piece on the results of compression tests made upon iron and steel, indicate that the shape of the test-piece does not affect the yield-point as regards magnitude, but that it does have considerable influence on the visibility of the point. The alteration in length increases as the ratio of the length to the square root of the cross-sectional area increases. Tests on similarly proportioned square and circular test-pieces show that the alteration in length of the square test-piece is greater than that of the circular one. The stress at the yield-point is materially affected by grain-size in such a way that, other things being equal, the yield stress decreases with increase of the grain-size. The linear relationship established by Kurth between the Brinell hardness or the yield-point and the degree of cold-working is confirmed. **F. C. A. H. L.**

**278.** *Trajectory of Projectiles shot out with a large Initial Speed, and at an Angle in the vicinity of 45°; Influence of Diminution in the Density of the Air.* **de Sparre.** (Comptes Rendus, 161. pp. 767–770, Dec. 20, 1915.)—Projectiles possessing a large initial velocity and projected at an angle of nearly 45° rapidly arrive at a region of the atmosphere where the density of the air is very much reduced—a circumstance which may augment the range by 30 to 40 %. The author calculates the trajectory by taking successive arcs and obtaining a first approximation by the method of Didion-Siacci, then estimating the corrections to be applied to the results of this first approximation, necessitated both by variation of air density and by the method itself. **H. H. Ho.**

**279.** *Falls of Droplet in Liquid and in Gas.* **O. W. Silvey.** (Phys. Rev. 7. pp. 87–105, Jan., 1916.)—To account for the apparent variation of the value $e$, Millikan wrote empirically the correction to Stokes' law as a function of the ratio of the mean free path to the radius of the drop, which, when higher powers of $1/a$ are neglected, reduces to the approximate formula—

$$v = \frac{2}{9}\frac{ga^2(\sigma-\rho)}{u}\left(1+\frac{\mathrm{Al}}{a}\right),$$

where $v$ is the velocity of fall, $a$ the radius of the spherical droplet, $\sigma$ its density, $\rho$ that of the surrounding medium, $u$ its viscosity, $\mathrm{l}$ the mean free path of the molecules in the medium, and A an empirical constant.

The present work is an elaborate series of experiments on the falls of mercury droplets in air and in xylol. Assuming that the modified form of Stokes' law is applicable to this motion, the value of 1·03 was found for the empirical constant A for the fall in air.

It was found that the Hadamard correction does not hold for mercury droplets in xylol.

A rough measurement of A from the apparent value of $e$ on mercury droplets gave a value in the neighbourhood of that obtained by using oil drops. [See Abs. 788 (1910) and 943 (1911).] E. H. B.

280. *Fall of Mercury Droplets in Viscous Medium.* **O. W. Silvey.** (Phys. Rev. 7. pp. 106–111, Jan., 1916.)—This experimental work on the fall of mercury droplets in castor oil gives results which lie almost exactly on the curve plotted from the Stokes-Ladenburg equation—

$$v=\frac{2}{9}\cdot\frac{a^2(\sigma-\rho)}{u(1+2{\cdot}4a/\mathrm{R})(1+3{\cdot}1a/\mathrm{L})},$$

where R and L are respectively the radius and length of the tube. The graph plotted on the same diagram for the Hadamard correction to Stokes' formula lies quite away from all the experimental results. [See Abs. 943 (1911) and preceding Abs.] E. H. B.

281. *Application of Nomography to Discontinuous Motion of a Liquid.* **W. B. Morton** and **E. J. Harvey.** (Phil. Mag. 31. pp. 130–138, Feb., 1916.)—In illustration of the use of nomograms the authors give seven nomograms and a set of curves, by means of which results in certain problems in discontinuous motion, here used as examples, can be readily obtained. L. H. W.

282. *Theory of the Capillary Tube.* **Rayleigh.** (Roy. Soc., Proc. Ser. A. 92. pp. 184–195, Jan. 1, 1916.)—In the theory of narrow tubes, the lower level from which the height of the meniscus is reckoned, is the free plane level. In experiment, the lower level is usually that of the liquid in a wide tube connected below with the narrow one, and the question arises how wide this tube needs to be in order that the inner part of the meniscus may be nearly enough plane. The analysis here developed to a first approximation gives for water a diameter of 4·74 cm. A second approximation gives 4·79 cm. E. H. B.

283. *Method of measuring Surface Tension and Angles of Contact.* **A. Anderson** and **J. E. Bowen.** (Phil. Mag. 31. pp. 143–148, Feb., 1916.)—This method depends on the measurement by optical means of the radius of curvature of the meniscus in a tube immersed in a vessel of the liquid and the height of the centre above (or below) the surface of the liquid outside. It is thus freed from any correction due to the mass of the meniscus and any uncertainty as to whether the liquid actually wets the glass. The curve connecting the radius of curvature thus determined and the radius of the tube at the top of the meniscus, for a number of tubes of different diameters, enables the angle of contact to be determined. These curves for water, glycerine, olive oil, and turpentine all appear to approach the origin at an angle of 45°, pointing to a zero angle of contact; mercury gives an angle of nearly 41° or, rather, a little greater than 139°. T. H. P.

284. *The Capillary Layer.* II. *Surface Tension and Curvature; Interpretation of the Labile Part of the Theoretical Isotherm.* **G. Bakker.** (Ann. d. Physik, 48. 6. pp. 770–798, Dec. 7, 1915.)—Studying the very thin inhomogeneous capillary layer [see Abs. 1374 (1915)] between the liquid phase and

vapour phase (*e.g.* of a drop of liquid surrounded by its saturated vapour) on the lines of Gibbs, the author deduces formulæ for any radius of curvature, Gibbs having confined himself to a relatively large radius. Stefan and Rayleigh have assumed that the thermal or kinetic pressure has the same value for a point in the capillary layer as for a point in a homogeneous phase of the same thickness, and this holds according to van der Waals also for the entropy. Thus the thermal pressure is given by $\theta = p + a\rho^2$, where $\rho$ is the density at the point in question and $p$ the pressure in the respective phase; each point of the capillary layer hence corresponds with a definite homogeneous phase of the theoretical isotherm. The resulting differential equations for the energy of the capillary layer has the same form as that for the homogeneous phase. The author had previously shown for a plane capillary layer that the pressure in the longitudinal direction (*i.e.* at right angles to the radial pressure) has the same value as the pressure of the homogeneous labile phase, for which the thermodynamic potential has the same value as for the homogeneous phases beyond the capillary layer. This conclusion is extended to curved layers, and may generally be expressed in the words: "The capillary layer between the two homogeneous phases of a liquid and its vapour may be regarded as representing the labile phase, the thermodynamic potential of which has the same value as that of the capillary layer." The theoretical isotherm may then be interpreted in the following way: "If in the diagram of an isotherm (for a certain temperature) for each capillary layer (spherical shell), which surrounds a spherical drop of liquid in the one case or a spherical bubble of vapour in the other case, the points are plotted representing the longitudinal pressures and the specific volumes of those capillary layers, then these points will form the labile part of the theoretical isotherm." This physical interpretation of the isotherm is much simpler than that given by the author in 1907. The external work expended in vaporisation can be resolved into four components, two of which concern the metastable phases and two the capillary layers. The paper is theoretical throughout. Some calculations on the thickness of the capillary layer are added; the values found are much higher than those of Kelvin. If the equations of state were fully known, this thickness could always be deduced.

H. B.

285. *Field of Two Spherical Fixed Centres in Einstein's Theory of Gravitation.* **J. Droste.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 760–769, 1916.)—In a previous paper the author calculated the field of a single spherical centre and investigated the motion of a particle in it. In the present paper the field of two fixed spherical centres is calculated according to the method followed by Lorentz in calculating the field of a single centre consisting of an incompressible fluid. The results furnish a first correction to the equations of motion as defined by classical mechanics and Newton's law. [See Abs. 636 (1915).]

E. H. B.

286. *The Blue of the Sky and Avogadro's Constant.* **D. Pacini.** (N. Cimento, 10. pp. 131–167, July–Aug., 1915.)—Rayleigh's theory attributes the blue of the sky to molecular dispersion; but we have also to do with dust and with molecular agglomerations (on ions, on uncharged nuclei produced by the action of ultra-violet light on oxygen, or on water-vapour) which are larger in size than the dimensions required by Rayleigh's theory, but which vary in size and number. The author has studied observed departures from the inverse fourth-power law, and tabulated the calculated

value of $n$ in $\lambda^{-n}$. It is mostly numerically smaller than 4, but has been found as large as 7. The observations are reduced to a series of typical curves, less or more in disaccord with the theoretical curve; and the probable causes of these discrepancies are considered. A perfect atmosphere would give data corresponding to about $62 \times 10^{22}$ molecules per gramme-molecule; the author finds his observations lead to a value of $57 \times 10^{22}$. Dember found by analogous methods 28, Abbot and Fowle 52, and King 62·8, $\times 10^{22}$. On the whole this is sufficient to show that the blue of the sky is mainly due to molecular dispersion. A. D.

287. *The Diurnal Variation of Underground Temperature.* **S. Sato.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 328–336, Dec., 1915. Tohoku Univ. Sci. Rep. 4. No. 5. pp. 393–405, 1916.)—The usual method of measuring earth temperatures is by hanging a mercury thermometer at the required depth in a metal tube sunk in the ground. In the present paper the temperatures recorded in a tube of this type are compared with those obtained by means of an electrical resistance thermometer buried in the soil. As the mercury thermometers ordinarily used were not of sufficient sensitiveness for a satisfactory comparison, an electric resistance thermometer was used in the earth tubes in place of the mercury ones. It was found that conduction of heat along the walls of the tube, and conduction and convection of the air column in the tube, caused the diurnal variation of the temperature in the metal pipe system to differ considerably in phase and amplitude from the curve of actual temperature changes in the soil at the same depth. Further, the error does not tend to vanish with increase of depth, but rather to increase. The ratio of the diurnal amplitude in the metal pipe system to the true amplitude at the same depth is given in the following table, together with the error in the phase angle.

| Depth. | 30 cm. | 40 cm. | 50 cm. |
|---|---|---|---|
| Ratio of amplitudes .................. | 1·88 | 2·18 | 2·62 |
| Phase-difference in hours............ | 7·5 | 10·25 | 13·5 |

Thus at 50 cm. depth the amplitude given by the metal pipe system is more than 2½ times the true value, and the maximum and minimum temperatures occur 13½ hours before the times of the corresponding extremes in the soil at the same depth. The absolute error in temperature commonly ranges up to between 0·5 and 1 deg. C. J. S. Di.

288. *Viscosity of the Earth.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 76. pp. 84–86, Dec., 1915.)—In continuation of a former paper [Abs. 1209 (1915)] it is argued that for a Eulerian nutation to be possible, it seems necessary that the time required for appreciable permanent set to take place must be several years; in such an earth bodily tidal friction must be very small in amount unless quite unknown laws are in operation. This appears to indicate that the theories of tidal lag as an explanation of the secular acceleration, and of the Eulerian nutation as an explanation of the 430-day period, are mutually inconsistent. C. P. B.

289. *Transparency of Aqueous Vapour.* **F. E. Fowle.** (Astrophys. J. 42. pp. 394–411, Dec., 1915.)—An attempt is made to treat quantitatively the depletion of energy from the radiation of heavenly bodies as it passes through

atmospheric aqueous vapour, the analysis dealing with *absorption* as contrasted with the *scattering* considered in former papers [Abs. 256 (1915)]. The loss of incoming solar energy is shown by tabulated values of solar radiation at two mountain stations, Mt. Whitney (4420 m.) and Mt. Wilson (1730 m.), and the sea-level station at Washington. The reduced values indicate the amounts of heat as calories and percentages of the incident energy (1·93 15° C. gm. cals.) scattered and absorbed at different air masses by dry air and by air containing various amounts of precipitable water. Curves are given indicating the fractional transmission of energy by dry air and by aqueous vapour, with the variations from wave-length to wave-length through the spectrum. C. P. B.

290. *Spectroscopic Determination of Solar Rotation.* **J. S. Plaskett.** (Astrophys. J. 42. pp. 373–393, Dec., 1915.)—Results are given of an investigation of the solar rotation from spectrograms obtained during 1912 and 1913 at the Ottawa Observatory, with the same apparatus as that used in previous work during 1911 [Abs. 53 (1914)]. In the later measures a reversing prism was used with the microscope eyepiece, so that readings corresponding to plate direct and plate reversed could be taken for each line before moving to another. The number of lines measured was reduced, as it appeared from the earlier measures that no systematic differences of velocity could be attributed to the use of different lines or lines of different elements. Two regions of the spectrum were recorded, one with plate at λ5600, the other with it at λ4250. For 1912, 25 plates were used for each region. For 1913, 20 plates at λ5600 and 17 at λ4250. In all 334 spectra were measured and reduced, involving the examination of over 11,000 lines. Tables are given summarising the reduced velocities on all the plates of 1912 and 1913 with the number and Greenwich mean date of each plate. Formulæ of the Faye type are given as the nearest approximation to the law of rotation for the different latitudes, that adopted for the linear velocity being $V=(2{\cdot}006-0{\cdot}522\sin^2\phi)\cos\phi$ km. per sec. Differences in the rotation velocities for 1911, 1912, 1913 are discussed from the point of view of their being instrumental or indicating real changes in the solar rotation. It is concluded that there is no evidence of rotation change, but the effects may be due either to errors of measurement or the influence of local movements in the material of the sun's reversing layer. C. P. B.

291. *Solar Rotation in* 1911. **J. B. Hubrecht.** (Solar Physics Observat., Cambridge, Ann. 3. 1. [77 pp.] Aug., 1915.)—This is the full account of the observations for determining the value of the solar rotation in June, 1911, a short summary having been already noted [Abs. 1213 (1915)]. Four series of plates were made during the first two weeks of June, 1911, at Cambridge, from which velocity-differences have been derived between pairs of points separated by 90° at intervals of 15° all round the sun's limb. Comparisons of results from different lines show a variation from one end of the spectral region to the other, smaller towards the red. The velocities appear to be arranged symmetrically with respect to a diameter inclined 0° 30′ with the assumed axis. With respect to the equator the sum of northern velocities is considerably greater than the sum of southern velocities. For solar latitude 45° the difference N–S = 0·052 km. sec. When averaged together to one quadrant and reduced to angular velocities the results are not in agreement with Faye's or any other simple law. The deviations occur especially at very low and at high latitudes. For these zones the angular velocity

is found to remain constant or even to increase with increasing latitude. All the observations seem to be consistent with Emden's solar theory.

C. P. B.

292. *Luminescence and Absorption in Solar Atmosphere.* **A. Perot.** (Soc. Int. Élect., Bull. 6. pp. 9–17, Jan., 1916.)—Examination of the spectrum of hydrogen in a specially made vacuum tube showed evidence of projection of the luminous centres with velocities varying from 49 to 1190 metres per sec. depending on the current strength in the tube (11 to 144 milliamps.). The velocity further appears to increase with decrease of pressure, but is affected by several other factors. Interesting results were found in the case of gaseous mixtures; with hydrogen and helium the velocities in the same tube for $H_\alpha$ and helium (λ5876) were distinctly different, in almost the order of the respective molecular weights. Again with lithium and sodium the velocities of λ6708 (Li) and λ5896 ($D_1$) were in the ratio of 1 : 3·1; the ratio of molecular weights being 1 : 3·3. The importance of these results is discussed with reference to the interpretation of solar spectra. C. P. B.

293. *Orbital Planes of Jupiter's Satellites.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 18. No. 6. pp. 1012–1017, 1916.)—Observations made on the four old satellites of Jupiter in the interval 1906–1909 by P. Guthnick at the Berlin Observatory were used to determine the position of the orbital planes of these bodies. Guthnick showed that the results agreed better with de Sitter's tables [see Abs. 1071 (1908)] than with the tables published by Sampson, and as this was only a preliminary examination, the author now gives a more complete comparison of the results with theory. Observations now being made at the Cape of Good Hope and Johannesburg are expected to furnish more valuable material. C. P. B.

294. *Cause of Divisions of Saturn's Rings.* **P. Lowell.** (Lowell Observatory Bull. No. 68. Nature, 96. p. 608, Jan. 27, 1916. Abstract.)—From the analysis of a series of micrometer measures of the rings of Saturn it is suggested that many of the newly-discovered divisions on ring B are due to the perturbations by Mimas, the nearest of Saturn's satellites. The chief argument is that most of the new divisions occur where a particle of the ring material would have a period of revolution commensurate in some simple ratio with that of Mimas. C. P. B.

295. *Influence of Fresnel-coefficient on Solar Phenomena.* **P. Zeeman.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 711–715, 1916.)—It is shown that the presence of the term $-\lambda/\mu \, . \, d\mu/d\lambda$ of Lorentz in the expression of the Fresnel coefficient may give rise to a change in the propagation of light-waves whenever a change of velocity occurs in a moving refracting medium. In the sun it is supposed there exists a radially rising, selectively absorbing, gaseous mass, in which a velocity gradient exists perpendicular to the radius. It therefore seems possible that under favourable circumstances the simultaneous existence of velocity gradients and anomalous dispersion in gases that are extremely rare and without density gradients, may give rise to a deflection of light. C. P. B.

296. *Anomalous Dispersion in the Sun.* **J. Evershed.** (Observatory, No. 496. pp. 59–62, Jan., 1916.)—From a study of the solar spectrum wavelength given by Rowland, S. Albrecht has suggested there is some evidence for the effect of anomalous dispersion in the solar atmosphere, giving a general

shift towards the red. It is shown by the present author that when direct measures of sun and arc spectra photographed together are made, little or no evidence is found to support Albrecht's conclusion. This direct comparison has been made by T. Royds at the Kodaikanal Observatory, and will shortly be published. Attention has been given to measurements of close double lines, which should show wider separation in the solar spectrum than in the arc if anomalous dispersion is effective. In the case of two test doubles examined, one gives no difference, and the other gives a difference in the wrong way. It has been shown (Kodaikanal Observatory Bull. No. 36) that the stronger solar lines are, in general, much more shifted than the weak lines, and this affords the more likely explanation of the differences observed. It is further shown that if bands due to anomalous dispersion were present to any extent, there should be a clearly marked difference between the width and character of the absorption-lines and the emission-lines of the chromosphere, but there appears to be no satisfactory evidence of this in eclipse spectra or high-dispersion solar spectra. C. P. B.

297. *Planetary Phenomena and Solar Activity.* **T. Köhl.** (Astron. Nachr. No. 4821. Nature, 96. p. 521, Jan. 6, 1916. Abstract.)—Jupiter's northern cloud belts appear to be specially weak at times of spot maxima, and become broader and more conspicuous during minima. The secondary light on the dark side of Venus is mentioned in relation to the occurrence of auroral displays on the earth. C. P. B.

298. *Nuclei of Comet a* (1915) *Mellish.* **H. E. Wood.** (Union of S. Africa Observatory, Circ. No. 31. p. 240, Oct. 27, 1915.)—On 1915 June 10, a series of four short-exposure photographs on one plate was obtained with the Franklin-Adams Star Camera, with durations of 1 to 5 mins. Several subsidiary nuclei are visible, situated on a line which is almost tangential to the coma on its south-preceding side. Measurements of position-angle and distance are included. C. P. B.

299. *Comet a* (1915) *Mellish.* **P. J. Melotte.** (Observatory, No. 496. pp. 53–54, Jan., 1916.)—Special interest seems to be attached to this comet on account of the presence of multiple nuclei on the photographs obtained of it at various times. Barnard announced that he had observed two supplementary nuclei, while Lowell observed four detached nuclei on May 24, receding from the head at a rate of 4″ a day. With the present article a reproduction is given from a photograph taken at the Sydney Observatory, on June 5, showing extra nuclei. Measures of position-angle and distance are given for June 5, 6, 8. Photographs taken on June 20 and 23 show little but the head of the comet with a single detached condensation. C. P. B.

300. *Radial Velocity of R Coronæ Borealis.* **H. Ludendorff.** (Astron. Nachr. No. 4823. Nature, 96. p. 521, Jan. 6, 1916. Abstract.)—Six spectrograms of this star were obtained during June 1913, and June 1915, while the object was at normal brightness. The spectrum resembles that of *a* Persei, and no signs of alteration were detected. The mean radial velocity from 6 plates is given as + 24·8 km. per sec. C. P. B.

301. *Precessional Constant and Systematic Proper Motions of Stars.* **E. F. van de Sande Bakhuysen** and **C. de Jong.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 683–695, 1916.)—From the work of Kapteyn it is regarded as established that stars of a given magnitude are at a greater mean distance

from us in proportion as they are nearer the galactic plane. At the galactic poles the mean parallax is found to be about 1¼ times as great as in the galactic plane itself. This systematic relation is shown to have some effect in the determination of the precessional constant and of proper motions, and by this means it is found possible to bring into fair agreement Newcomb's results for the precessional constant found from R.A. and Decl. C. P. B.

302. *Spectra of Wolf-Rayet Stars.* **M. Wolf.** (Astron. Nachr. No. 4824. Nature, 96. p. 521, Jan. 6, 1916. Abstract.)—In the case of several Wolf-Rayet stars their spectra are found to show evidence of oscillatory variability similar in type to that so characteristic of the later stages of novæ. These are well shown in the hydrogen bands, especially $H_\delta$; the absorption lines appear sharp at some times, at others masked and weakened. C. P. B.

303. *Photoelectric Photometry of α Cygni.* **P. Guthnick and R. Prager.** (Astron. Nachr. No. 4828. Nature, 96. p. 521, Jan. 6, 1916. Abstract.)—Observations with a photoelectric photometer confirm the suspected variability of α Cygni, the range being 0·07 mag. It is also stated that variations have been detected in α and γ Lyræ. C. P. B.

304. *Mutual Repulsion of Contiguous Spectrum Lines.* **J. Larmor.** (Observatory, No. 497. pp. 103–104, Feb., 1916.)—In reference to the notes by J. Evershed and T. Royds [Abs. 296 (1916)] it is pointed out that a substance capable of emitting a spectrum line raises anomalously the index of refraction of an atmosphere, in which it exists, for adjacent light on the red side of the line, and lowers it on the violet side. Thus another line very near the line above considered and on its red side will be displaced towards the red; and similarly a line on the violet side will be displaced to the violet. In fact very close spectrum lines ought to repel each other, subject to the two lines representing independent vibrations. On this theory the displacement of a line is proportional to the density of the substance that is present and is producing the adjacent disturbing line, and this may be of value in the interpretation of stellar spectra. C. P. B.

305. *Structure of Third Cyanogen Band.* **H. S. Uhler and R. A. Patterson.** (Astrophys. J. 42. pp. 434–468, Dec., 1915.)—Photographs of the bands characteristic of the carbon arc in air, between λ3590 and λ3883, have been made with the large Rowland grating spectrograph at Baltimore, using the third-order spectrum, and also with an Anderson grating at Yale University, using the second and fourth orders. Tables are given showing the wave-length of the lines on the international scale, with detailed reference for the character of such line as regards its relation to the band structure, and special mention is made of the appearance of the so-called tails between λ3658 and λ3128. Curves are given showing the first differences of wave-length plotted against a wave-length scale, and a deviation from Deslandres' law is clearly indicated. In the resulting discussion of the bearing on Thiele's hypothesis regarding tails, it is concluded that there is no indication of any of the so-called tails being directly connected with the λ3883 band, and that, in agreement with Weiss, the only experimental evidence of Thiele's hypothesis is the occurrence of band structures shading off towards the red, and the existence of maximum intervals between the lines of the same series.

Measurements of a new band extending from λ3280 to λ3340 are given. C. P. B.

**306.** *Iron Arc Lines near Strong Calcium Lines.* **E. G. Bilham.** (Astrophys. J. 42. pp. 469–472, Dec., 1915.)—In the standardisation of spectrum wave-lengths various small differences have been detected which appear in some way to depend on the method of production or environment of the light-sources [Abs. 1431 (1913), 1983 (1914)]. In the present paper the author examines the possibility that a very strong line due to an impurity may be capable of producing displacements of lines of the predominating substance in the immediate neighbourhood. Photographs were taken in the third order of a 10-ft. Rowland concave grating, using a carbon arc fed with iron filings, and then again with calcium chloride added. A number of iron lines in the vicinity of the strong H and K lines of calcium were measured on all the plates with reference to selected standards given by Burns. Only two iron lines show appreciable evidence of shift, and one is an unsymmetrical line difficult to measure. A shift of 0·006 Å. was found for the line λ3970·4, which may be due to the proximity of the heavy impurity line. C. P. B.

**307.** *Catalogue of Spectra of* **354** *Faint Stars.* **J. N. Lockyer.** (Hill Observat., Sidmouth, Vol. 1, Bull. 3. [10 pp.] Oct., 1915.)—The catalogue is an extension to the fainter stars of the Kensington Catalogue of the spectra of 470 of the brighter stars published in 1902. The new spectra have been photographed with the 12-in. McClean prismatic camera presented to the Hill Observatory, in conjunction with an objective prism of 20° refracting angle. The spectra give a dispersion of 28 mm. from $H_\beta$ to K. The list gives for each star the designation, position for 1900, magnitude, Harvard classification and Hill Observatory classification, the latter being on the same plan as is the previous Kensington Catalogue, treating the spectra as indicating series of ascending as well as descending temperature. C. P. B.

**308.** *Variable Nebula N.G.C.* 6729. **H. K. Shaw.** (Helwân Observat. Bull. 16. Nature, 96. pp. 575–576, Jan. 20, 1916. Abstract.)—From a photographic study of the fan-shaped nebula in the vicinity of the variable R Coronæ Australis it is found that the nebula appears bright simultaneously with the variable. Selectively variable areas of the nebula have also been noted. C. P. B.

**309.** *Colours of Stars in Clusters N.G.C.* 1647 *and M.* 67. **F. H. Seares.** (Nat. Acad. Sci., Proc. 1. p. 483, 1915. Nature, 96. pp. 633–634, Feb. 3, 1916. Abstract.)—Summaries are given of the colours of the stars in the two clusters, using the colour-classes recently proposed by Hertzsprung and Seares. It appears that in neither cluster does the colour or magnitude vary with the degree of condensation, but colour and magnitude also show a decided interrelationship, more marked in the cluster N.G.C. 1647 than in M. 67. C. P. B.

**310.** *Motions and Distances of Bright Stars of Type F.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 76. pp. 121–135, Dec., 1915.)—A statistical analysis is made of 140 bright stars of spectral type F, similar to that made for the type A stars [Abs. 1390 (1915)]. These stars are, broadly speaking, of two classes, designated *peculiar* and *normal*. It is shown that a star with peculiar spectrum is on the average 100 times brighter than a star of the same type with a normal spectrum, thus linking up the analysis with the idea of giant and dwarf stars outlined by Hertzsprung and Russell. C. P. B.

**311.** *Astrographic Magnitude Scales.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 76. pp. 149–157, Dec., 1915.)—In continuation of former notes [Abs. 278, 824 (1915)] tabulations are given of the counts of stars from the Toulouse astrographic photographs, grouped under their respective magnitudes and right ascension.

Further data from photographs taken at the Cape of Good Hope are examined to detect evidence concerning the regions thought to contain obscuring matter, these patches roughly forming a spiral round the sky whose median line is $\alpha + 4\delta = 260°$. Treating the data harmonically gives a closer approximation to the curve. The region of obscuration appears to be bounded sharply on the side of smaller R.A. in the northern hemisphere, and sharply on the side of greater R.A. in the southern hemisphere. C. P. B.

312. *Distribution of Stars in Globular Clusters.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 76. pp. 107–121, Dec., 1915.)—Taking as basis the counts of stars in various star clusters published by Bailey, an investigation is made to determine how far the arrangement of the individual stars follows a law analogous to the law of density in a spherical mass of gas in convective equilibrium. In the case of the well-known cluster $\omega$ Centauri the gaseous law was found to be very closely followed, while in many clusters the only discrepancy is in the region of the centre, where naturally the counts are less reliable. The greatest divergence from the theoretical distribution is in the cluster M3. It is suggested that it may be convenient to distinguish between open clusters and those possessing a distinct nuclear structure. C. P. B.

313. *Faint Stars with Large Proper Motions.* **F. A. Bellamy.** (Roy. Astron. Soc., M.N. 76. pp. 102–104, Dec., 1915.)—From the comparison of two plates taken on 1896 April 11, and 1911 May 24, details are furnished of the proper motions of 9 faint stars, the range being from 9·9 to 26·8 seconds of arc in a century. C. P. B.

314. *Theory of Star-streaming.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 76. pp. 70–84, Dec., 1915.)—In a detailed examination of the Schwarzschild ellipsoidal law, it is shown to be possible only in a universe of spherical shape when a steady state is considered. It is then found that even without any restriction as to distribution law the facts of star-streaming as already determined are not consistent with the idea of a universe in a steady state. The conditions for which the different parts of a universe should be dynamically in equilibrium are also investigated, with the conclusion again that our universe is not in a state of equilibrium. C. P. B.

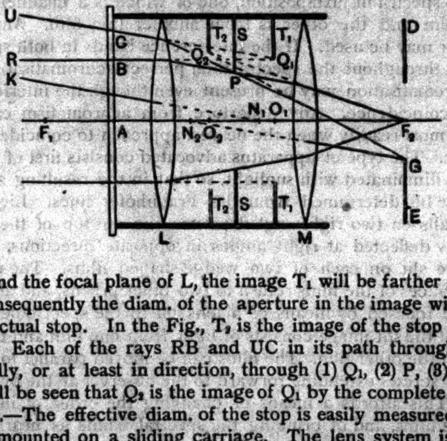
315. *Aurora Borealis Observations at Bossekop.* **C. Störmer.** (Terrest. Magn. 20. pp. 159–174, Dec., 1915.)—In continuation of preliminary accounts of observations of aurorae made during the spring of 1913 [Abs. 1236 (1915)] a detailed discussion is now given of material obtained on the nights March 14, 15 and 15, 16, 1913, during which about 100 auroral photograms were secured. These, being taken in duplicate with similar cameras some kilometres apart, afforded means of accurately determining the heights of the streamers. These calculated heights are collected in a diagram showing that the majority of the auroral points are produced in a localised zone about 100 km. from the earth's surface. Indications are shown of two accumulations at heights of 101 and 106 km., and isolated aurora have given heights up to 200 km. Several interesting photographs are reproduced, showing the difference as seen at the two stations, with identified stars for facilitating the localisations. A spectrogram of the aurora of March 14, 1913, is also presented, but no identifications of the bands are supplied. Diagrams are also given showing the projection of the points of the earth's surface lying in the same earth-radius with each auroral point measured. C. P. B.

## LIGHT.

**316.** *Achromatoscope.* **S. R. Williams.** (Am. J. Sci. 41. pp. 101–111, Jan., 1916.)—The first part of this paper discusses in some detail the spectral bands obtained when the image of a set of Newton's rings is projected by reflection on the slit of a spectrometer. The latter part deals with methods of utilising such bands for the study of transparent substances in order to find achromatic combinations. Preliminary work in testing the achromacy of various liquids would indicate that for some purposes liquid lenses might be used to great advantage. The liquids would have to be held in glass containers ground to the proper curvature and having parallel walls. The arrangements adapted to testing substances for achromatic combinations have been called achromatoscopes because without the necessity of measuring the refractive indices we can tell by inspection whether there is achromacy or not. The various systems consist essentially of devices for viewing two spectra in juxtaposition, one of which is a channelled spectrum from one film and the other is from another thin film. Any comparison spectrometer may be used. If the interference bands in both spectra are in coincidence throughout the spectra then perfect achromatisation exists, but perfect achromatisation may be present even though the interference bands are not in coincidence. Any departure from achromatism can, however, be detected most readily when the nearest approach to coincidence of bands is sought for. The type of apparatus advocated consists first of a collimator, whose slit is illuminated with sunlight, so that in the resulting spectra wave-lengths may be determined from the Fraunhofer lines. Light from the collimator falls on two right-angled prisms one on top of the other. The beam is thus deflected at right angles in opposite directions, throwing an image of the slit on each of two wedge-shaped films. The rays reflected from the surfaces of the films return to two other prisms, and after reflection by these are focused by means of a lens on to the spectrometer slit. The upper half of the slit image consists of light from one film and the lower half of light from the other film. The films can be moved parallel to their lengths by means of screws extending forward to the observer at the eyepiece of the telescope. This affords a means of changing the order of interference in either of the films, and of bringing the spectral bands as nearly as possible into coincidence. A very simple device for mounting two films in comparison work is illustrated. The films are fastened edge to edge in a frame, which is placed before the slit of the spectrometer at an angle of about 45° with the axis of the collimator tube. The sunlight reflected from the upper film may be made to illuminate the upper half of the slit, while that from the lower film will illuminate the lower half of the slit. This does not permit shifting one film with respect to the other, though such an arrangement could easily be made. A. W.

**317.** *Determination of Effective Aperture of the Stop of a Photographic Lens.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 18. pp. 195–206, Jan., 1916.)—The "*f*" and the U.S. system (Uniform notations) for stops are first described.

When the stop S is placed in front of the lens system, as was often the case in the older photographic lenses, its effective diam. for landscape work is simply equal to the actual diam. of the stop itself. A stop does more than merely regulate the amount of light passing through the lens. The position of a stop of given aperture has an important influence upon the effects of the five "defects" of a lens, viz. upon the effects of spherical aberration, coma, astigmatism, curvature of image surfaces, distortion; in the case of modern lenses consisting of two separated components, it is found that it is advantageous to place the stop between the components, as in accompanying Fig. The effective diam. can be calculated from the actual diam. when the position of the stop relative to the two components and also the optical constants of the components are known, but it would be troublesome to obtain all these data. It is better to treat the lens system as a whole, and to arrange the measurements so that there is no need to take the lens system to pieces. Let S be the stop, and let $T_1$ be the image of S formed by the front lens L; then S is the image of $T_1$ by the same lens. Hence, a ray $RQ_1$, which before incidence on the lens L is parallel to the axis $AF_2$, and is directed to a point $Q_1$ on the edge of $T_1$, will, after traversing L, pass through P, the corresponding point on the edge of the stop itself. It is clear, therefore, that the distance of the ray $RQ_1$ from the axis $AF_2$ is equal to the radius ($a/2$) of the effective aperture. If the front lens L is a converging lens, and if the stop S lies between L and the focal plane of L, the image $T_1$ will be farther from L than S is, and consequently the diam. of the aperture in the image will be greater than in the actual stop. In the Fig., $T_2$ is the image of the stop S formed by the lens M. Each of the rays RB and UC in its path through the system passes actually, or at least in direction, through (1) $Q_1$, (2) P, (3) the edge $Q_2$ of $T_2$. It will be seen that $Q_2$ is the image of $Q_1$ by the complete lens system. *First method.*—The effective diam. of the stop is easily measured by aid of a microscope mounted on a sliding carriage. The lens system is firmly supported with its axis horizontal. The microscope is attached to the carriage so that its axis is at right angles to the direction of motion of the carriage, and the track on which the carriage slides is placed so that the axis of the microscope is parallel to that of the lens system, the two axes being at the same height above the table. The microscope is then focused through the lens L upon one end of the horizontal diam. of the stop, and the sliding carriage is adjusted so that the image of the edge of the stop is brought to coincidence with the cross-wire of the microscope or with a selected dividing line of the micrometer scale. The carriage is then moved along its track so as to bring the image of the other end of the diam. to the cross-wire or to the same micrometer division as before. The distance through which the microscope has been moved is equal to *a*, the effective diam. of the stop. *Second method.*—If a luminous point were placed at the focus $F_2$, the rays from it, after passing through the system, would form a beam of rays parallel to the



axis $AF_2$. If a glass scale were placed against the mount of the lens as ABC, the diam. of the beam of light could be at once read off, provided that face of the scale which rests against the mount has a suitable matt surface. The divided face of the glass scale should rest against the mount. The diam. of the bright patch on the scale is equal to the effective diam. of the stop. The practical method of obtaining a beam of rays from a small area in the focal plane is described. But, since the rays do not now proceed from a point, the emergent beam will not be made up only of rays that are parallel to the axis, and, consequently, the diam. of the bright patch on the scale ABC will no longer be equal to the effective diam. of the stop. The necessary correction is, however, easily found. *Third method.*—The determination of the distance $BQ_1$ required by second method may be avoided by using two plates with apertures of diams. $d_1$ and $d_2$. Let $c_1$ and $c_2$ be the diams. of the corresponding bright patches on the matt surface of the glass scale. Since $c - a$ is proportional to $d$, $(c_1 - a)/(c_2 - a) = d_1/d_2$. Thus—

$$a(d_1 - d_2) = c_2d_1 - c_1d_2 = c_1(d_1 - d_2) - d_1(c_1 - c_2),$$

and hence—

$$a = c_1 - d_1(c_1 - c_2)/(d_1 - d_2).$$

A system for laboratory work is also given. The mathematics relative to the effect of distance of object on effective aperture is dealt with in detail.

A. E. G.

318. *Experiments with Prism of Small Angle.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 18. pp. 155–170, Jan., 1916.)—Describes a number of laboratory experiments made with small-angle prisms, use being made of an auto-collimating goniometer of simple design. The experiments form a useful introduction to work with lenses.

A. W.

319. *Reflection from and Transmission through Rough Surfaces.* **A. F. Gorton.** (Phys. Rev. 7. pp. 66–78, Jan., 1916.)—The original pages should be referred to for the numerous curves of relative reflecting powers of the substances investigated. The author summarises his results as follows:—(1) A study of the reflecting power of matt surfaces at various angles of incidence and of the transmission of roughened plates of rock-salt, in the region $0.6\,\mu$ to $18\,\mu$, has been made for the purpose of finding a suitable screen for cutting off the short waves. (2) The best results, in the case of reflection, were obtained with the finest surfaces used at rather great angles of incidence. Experiments showed that a surface of plate glass, which had been ground uniformly with the finest emery and then silvered, when used at an angle of 75°, reflected 90 % at $4\,\mu$, approaching 100 % for longer wavelengths, and only 10 % at $1\,\mu$, less than 5 % in the visible red, approaching zero for the shorter waves. Very similar results were obtained for the transmission of a plate of rock-salt which had been roughened merely by breathing gently upon it. In both cases, the finer the surface the more suddenly does it cut off the short waves. (3) Increasing the angle of incidence was observed to effect a profound and curious change in the reflection curves of polished glass, quartz, and Iceland spar, which may best be described as a quasi-resolution of the bands of metallic reflection. This is thought to be due to a change in polarisation at the reflecting surface (*i.e.* a change probably from plane-polarised to elliptically-polarised light).

A description is given of an infra-red spectrometer which is believed to possess better definition and greater resolving power than is usually furnished by instruments of similar type.

L. H. W.

320. *Theory of the Flicker Photometer.* **H. E. Ives** and **E. F. Kingsbury.** (Phys. Rev. 7. pp. 149–150, Jan., 1916. Abstract of paper read before the Am. Phys. Soc., Oct. 30, 1915.)—It is found, experimentally, that with a flicker photometer:—(1) Different ratios of light to dark exposure under constant illumination call for varying critical speeds. At high illuminations a maximum occurs for approximately equal light and dark intervals, but the curves connecting relative period of light exposure and critical speed are not symmetrical. (2) At low illuminations, using blue light, the maximum at equal light and dark exposures is absent, the critical speed increasing continuously as the ratio of the light to the dark interval is decreased. (3) The relationship between illumination and critical speed is represented by the equation, speed $= a$ log. (illumination) $+ b$, where $a$ is a constant independent of the relative light and dark exposures, while $b$ is another constant varying with this factor. (4) When a flickering illumination is superposed on a steady one, the critical speed is connected with the mean illumination by the same equation as in (3) above, but the constant $a$ varies with the ratio of flickering to steady illumination. (5) The high sensitivity of the flicker photometer is due to the very rapid increase in the critical frequency of disappearance of flicker on each side of the equality setting. (6) In a flicker photometer which exposes the compared colours for unequal periods, the less exposed colour will be underrated. (7) Mechanical imperfections in the flicker photometer field seriously shift the equality point even with no colour-difference, and this makes it necessary to employ substitution methods in flicker photometry.

These experimental results may be explained on the theory that the behaviour of the visual apparatus towards intermittent light is closely analogous to the action of a layer of matter, obeying the Fourier conduction law, in which the diffusivity varies as the logarithm of the intensity of the illumination, this layer being exposed to the intermittent light in one side, while its condition on the other side is measured by an instrument whose sensitivity is governed by Fechner's law. [See Abs. 298 and 299 (1915).]

J. W. T. W.

321. *Establishment of Photometry on a Physical Basis.* **H. E. Ives.** (Frank. Inst., J. 180. pp. 409–436, Oct., 1915.)—The paper partly covers the ground of previous communications [Abs. 547 and 1641 (1915)]. The author explains the distinction between photometric readings based on the impressions of the eye, and readings of physical instruments (thermopiles, etc.). He describes two instruments intended to serve as physical photometers. In both cases the light to be tested is received on a thermopile, but special means are found to make the response of the thermopile equivalent to visual effect. In one case a cell containing a special solution is placed in front of the instrument, thus diminishing the radiation throughout the spectrum in such proportions as to give a luminosity curve identical with that of the eye. In the other case the same result is obtained by a different method—namely, by forming the spectrum of the illuminant studied, cutting down the light at each point in the spectrum by means of specially shaped screens, and then recombining the elements again. The energy remaining after such a process is small, and the galvanometer must therefore be highly sensitive. The physical photometer is specially useful for measuring the absorption of solutions. Finally the author gives the results of some tests of the luminous efficiency of various sources. He suggests that the above researches may lead to a definition of intensity of light in terms of energy (measured as watts) of specified composition.

J. S. D.

**322.** *Properties of Tungsten Filaments and Mechanical Equivalent of Light.* **I. Langmuir.** (Phys. Rev. 7. pp. 152–154, Jan., 1916. Abstract of paper read before the Am. Phys. Soc., Oct. 30, 1915.)—Measurements of volts, amps., and candle-power, expressed as functions of the filament temperature, were made on 15 specially constructed lamps, correction being made for cooling at the ends of the filaments. The following quantities are tabulated from the results obtained :—(1) Specific resistance, R. (2) Resistance exponent $n_R = d$ log. R/$d$ log. T. (3) Watts radiated per cm.² of surface (bulb at 298° K.). (4) Watt exponent $n = d$ log. W/$d$ log. T, where W = watts radiated into space at 0° K. (5) Total emissivity. (6) Intrinsic brilliancy (candles per cm.²). (7) Colour, expressed as the temperature of a black body emitting light of the same colour. Using Nutting's visibility data the mechanical equivalent of light is found to be 0·00121 watt/lumen. [See Abs. 838 (1915), also Abs. 338 (1916).] J. W. T. W.

**323.** *Arc and Spark Spectra of Nickel under Pressure.* **E. G. Bilham.** (Phil. Mag. 31. pp. 163–170, Feb., 1916.)—In a recent paper [Abs. 1406 (1915)] Duffield has made a detailed comparison between the results of his investigation of the effects of pressure on the arc spectrum of Ni, and those of Bilham [Abs. 1983 (1914)], in which the mode of excitation was the spark between Ni electrodes connected to the secondary coil of a resonance transformer. In the present paper Bilham criticises some of Duffield's conclusions and points out possible sources of error in the latter's readings at pressures of about 10 atmos. It appears that the temperature effect with a large grating mounted in the Rowland manner, as was employed by Duffield, might account for the whole of the observed discrepancies between his results at 10 atmos. and those of Bilham. Results obtained by Humphreys and Mohler also tend to show that Duffield's measurements at 10 atmos. are, on the whole, too high. This view then leads to the conclusion that the behaviour of lines easily reversed, or tending to reverse, is approximately the same whether developed in the arc or spark under pressure. Abnormalities or discrepancies are exhibited by unreversed lines. This result is exactly the opposite of that reached by Duffield's analysis of the data and is supported by the theory the author gives concerning the part played by the density and temperature gradients. Further investigation will be necessary to decide which view is correct. A. W.

**324.** *Spectra of Kathode Metals.* **P. E. Robinson.** (Astrophys. J. 42. pp. 473–478, Dec., 1915.)—Many workers with vacuum tubes have observed lines of the metals composing the electrodes in the spectra of the gases in the tubes. These lines are strongest near the kathode, though in working with an induction coil they may also appear at the anode, especially if the inverse current is marked. Goldstein investigated this phenomenon [Abs. 345 (1905)]. He found that the lines of many metals, 15 in all, used as kathodes, appeared, but only if the gas in the tube was nitrogen, and that the brilliancy of the metallic spectrum was greatly enhanced by immersing the vacuum tube in liquid air. The present paper records the preliminary results of work along the same line. The final tube used, 1·2 cm. internal diam., was H-shaped, with four electrodes of different metals, one in each branch. This made possible the investigation of four different metals under similar conditions. The central portion of the tube gave an end-on discharge of the gas free from the kathode spectrum. The kathodes were discs of metal nearly filling the cross-section of the tube, and were pierced with numerous small holes. An induction coil capable of giving a 15-cm. spark was employed, the voltage in the primary circuit generally being 18, occasionally 24 volts. Variations in the voltage did not seem greatly to affect the production of the kathode spectrum, but a condensed discharge was usually more effective than a discharge without a condenser. Early experiments showed that the kathode should be thin. No evidence of metallic lines was obtained with kathodes 1-2 mm. thick, but later experiments lead to the view that a thick electrode pierced with numerous small holes might be used successfully. Increased temperature appears to strengthen the kathode spectrum, although it does not seem necessary for its production. While the kathode spectrum is obtained with most ease in nitrogen, it can be produced in other gases as well. For obtaining the spectrum there is a most favourable pressure, which varies with the gas in the tube and with the material of the kathode. The range of pressure over which the kathode spectrum is easily excited is large for nitrogen. This probably explains in part why Goldstein should have found the kathode spectrum in nitrogen only. It has now been obtained in hydrogen, in carbon monoxide, and with especial brilliance in oxygen. The spectra have been photographed, and the wave-lengths determined. The spectra were found to be the spark, rather than the arc, spectra. A comparison of the results with Kayser's tables shows that while in general only the stronger lines given by Kayser have appeared in these experiments, yet many strong lines have not, and many faint ones have been recorded. Furthermore, the selection of lines and their relative intensities depend on the gas in the tube. The spectrum of copper is the only one which has been examined at all thoroughly. Al, Fe, and Ag were examined visually. The results may be roughly summarised by saying that conditions favourable to the sputtering of the kathode were found to favour excitation of the spectrum of the metal of the kathode. A. W.

**325.** *Absorption Spectra of Blue Solutions of Sodium and Magnesium in Liquid Ammonia.* **G. E. Gibson** and **W. L. Argo.** (Phys. Rev. 7. pp. 33-48, Jan., 1916.)—Kraus has shown that the electrical properties of solutions of metals in liquid ammonia can be explained on the assumption that the atoms of the metal dissociate into electrons partly combined with the solvent and into kathions present in solution of its salts in ammonia. Different metal solutions exhibit a blue colour, and the authors have made measurements of the visible absorption spectra of dilute solutions of Na and Mg in liquid ammonia in order to test the assumption that the colour is due to the unsolvated portion of the electrons resulting from this dissociation.

Solutions of sodium and magnesium of the same colour intensity were found to have the same absorption spectrum. Beer's law appears to hold for the total dissolved metal. Qualitatively the evidence obtained favours the assumption that the absorption is due to the unsolvated electrons, but quantitatively the measurements cannot be interpreted in terms of Drude's theory of metallic dispersion.

A Grünbaum and Martens spectrophotometer was used for measuring the extinctions, and the authors describe very fully their special quartz absorption-cell and the details of its manufacture. C. S. G.

**326.** *Oxy-hydrogen Flame Spectrum of Iron.* **N. Lockyer** and **H. E. Goodson.** (Roy. Soc., Proc. 92. pp. 260-265, Feb. 1, 1916.)—The paper gives measurements of the flame lines of iron taken with a 3-in. Cooke prism spectrograph. The spectrum is compared with that of the iron arc obtained by various experimenters and under different conditions. As a result the flame lines are classed into three groups, A, B, and C, respectively stronger than, weaker than, and of approximately equal intensity to the corresponding arc lines. Further, reference is made to the behaviour of these three groups in solar, sun-spot, and stellar spectra.

The stellar behaviour of the iron flame-lines of group A is exactly in accord with their behaviour in the sun-spot spectra as compared with the Fraunhoferic, and also just what would be expected from their laboratory behaviour. C. S. G.

327. *Production of Light by the Recombination of Ions.* **C. D. Child.** (Phil. Mag. 31. pp. 139–143, Feb., 1916.)—In a recent paper [Abs. 167 (1915)] describing experiments on the luminous vapour distilled from the mercury arc Strutt reaches the conclusion that the light given off by the vapour comes from the positive ions, while the author of the present paper has concluded that the light does not come from either the positive or the negative ions alone, but from the two at the time of recombining [see Abs. 320 (1914)]. Various reasons are now adduced in support of this latter idea. Child points out that Strutt's argument is not conclusive, since the rate of recombination is not necessarily reduced by one-half when the number of negative ions passing a given point is reduced by one-half. The rate of recombination depends on the number in a region at a given time, and this depends not only on the number passing a given point but also on their velocity after the point is passed. If, for example, the number of negative ions passing a point and the velocity with which they move are both reduced one-half, then the number of ions per unit volume is not changed, and the rate of recombination is the same as at first. This explanation will meet all the conditions of Strutt's experiments. Other facts lead to the conclusion that the number of negative ions per unit volume between the electrodes is very approximately the same as that of the positive ions, so that the assumption that the light is due to recombination is entirely reasonable. The discussion does not claim that all light is produced by recombination. If, as has been found by Strutt, the luminous vapours rising from the As and Sb arcs are not affected by the electric field, there is no reason to think that such light is produced by the recombination of the ions, but such an experiment would prove equally well that this light does not come from the positive ions. If the light from As and Sb vapours does not behave in an electric field in the same way as that from Hg and Na vapours, it seems more reasonable to assume that the light is produced by some different mechanism. A. W.

328. *Notation of Zeeman Patterns.* **W. M. Hicks.** (Phil. Mag. 31. pp. 171–173, Feb., 1916.)—The convenience of a generally recognised and concise notation to represent the configuration of the components when a spectral line is decomposed in a magnetic field is evident. Runge has shown that the displacements of the various components in a given field are multiples or sub-multiples of a constant unit. The wave-number displacement chosen by him as the unit is that of the normal triplet. The author takes as unit a value one-third of this, in order to avoid the frequent appearance of fractions. Using the determination from Cd and Zn by Stellenheimer the constant is given by $10^{-5}d\lambda/\lambda^2H = 1{\cdot}584$. As the displacements take place in general symmetrically on both sides of the undisplaced line, it is only necessary to tabulate those on each side and to indicate the distances as multiples of the unit.

With the notation suggested the patterns for the various kinds of series are shown. A. B. W.

**329.** *Fluorescent and Intensifying Screens.* **L. A. Levy.** (Röntgen Soc., J. 12. pp. 13–18; Disc., 18–22, Jan., 1916.)—A considerable number of different chemical substances have been employed from time to time in order to produce the active or fluorescent coating. The substance which has by far the most extensive application is the familiar barium platinocyanide. The salt used for fluorescent screens is a double cyanide of barium and platinum, $BaPt(CN)_4, 4H_2O$, containing four molecules of water of crystallisation. This substance is capable of existing in three forms, all of which are chemically identical, but which nevertheless display totally different physical properties. The following table gives the details :—

| Physical Properties | Crystalline A | Crystalline B | Amorphous |
|---|---|---|---|
| Colour ............... | Orange | Apple Green | Brick Red |
| Crystalline Form ... | Identical | Identical | None |
| Fluorescence......... | Very Feeble | Very brilliant | None |

The green salt is 50 times as efficient as the orange-yellow crystals. These two varieties of barium platinocyanide also differ in their specific gravity. As a result of a large number of experiments, the author has come to the conclusion that the differences must be due to a special case of stereoisomerism, that is to say to a difference in the method in which the individual atoms, molecular groups, and molecules of water of crystallisation are arranged around the central Pt-atom. If some of the crystals of the green or yellow salt are powdered in a mortar the powder turns to a brick-red amorphous variety, and at the same time loses its fluorescence. It is usually said that the change from the green fluorescent to the red and non-fluorescent salt is due to dehydration. This is apparently borne out by the fact that the dehydrate of barium platinocyanide, with two molecules of water of crystallisation instead of the usual four, is brick-red and non-fluorescent. This, however, is not the correct explanation—the real cause is the change from the crystalline to the amorphous condition, and the effect is the same whether produced by X-rays or mechanical means. This change of state from crystalline to amorphous, which also means the progressive destruction of the screen, can be inhibited by the use of a special method of preparation of the salt. For this reason the salt used for screen-making is totally different from the salt employed for exposure pastilles.

Zinc sulphide is another body which has been used to a small extent for screen-making. Zinc sulphide prepared in the form of hexagonal crystals is known as hexagonal zinc blende. In this form it displays fluorescence, phosphorescence, and other luminous characteristics, and finds its chief application in the admixture with radium salts for the manufacture of luminous dials for watches, etc. This form of the substance displays a considerable after-phosphorescence which renders it quite useless for screen-making. This phosphorescence can be destroyed by suitable treatment and a fluorescent substance results which displays no phosphorescence. Screens made of this material respond very well to very soft radiations and show the details of flowers, very fine pieces of Al, etc. They are, however, practically useless with hard radiation. For this reason, and also because of the peculiar orange colour of the fluorescent light, these screens have found but little application. The chief requisites of an intensifying screen are :—(1) It should effect a considerable reduction of the time of exposure. (2) It should yield negatives free from grain and blurring. (3) It should not display any appreciable after-phosphorescence, as this invariably leads to fogging of the negative. The salt employed, calcium tungstate, is specially chosen to yield fluorescent light of a blue colour, as this has by far the most effect chemically upon the sensitive emulsion.

The radiographs which accompany this communication have been made in order to determine the best method of using intensifying screens. A. E. G.

330. *Maximum Frequency of X-rays at Constant Voltages between* 30,000 *and* 100,000. **A. W. Hull.** (Phys. Rev. 7. pp. 156–158, Jan., 1916. Paper read before the Am. Phys. Soc., Nov., 1915.)—Rutherford [Abs. 1417, 1418 (1915)] has described experiments with a Coolidge tube in which the max. frequency of X-rays at different voltages was calculated from the absorption coefficients of the total radiation after a sufficient part of it had been absorbed to make the absorption coefficient nearly constant. He found that the max. frequencies determined in this way did not increase linearly with the voltage, but less rapidly, and reached a maximum at 140,000 volts.

The author's experiments on the same question show no evidence of a maximum, the frequencies for voltages up to 100,000 being given accurately by the quantum relation $eV = h\nu_{\text{max.}}$, *i.e.* the max. frequency is a linear function of the applied voltage. To explain the departure from the linear relation observed in Rutherford's experiments, it is suggested that the absorption method does not give the max. frequency. This point has also been mentioned by Duane [Abs. 1419 (1915)]. A. B. W.

## RADIO-ACTIVITY.

331. *Life of Radium.* **E. Gleditsch.** (Amer. J. Sci. 41. pp. 112–124, Jan., 1916.)—The author has made a series of measurements of the growth of radium in solutions of ionium preparations separated from different uranium minerals—namely: (1) from uranite (North Carolina), (2) from clevite (Norway), and (3) from bröggerite (Norway). The results obtained from the first two minerals indicate that the constant of change of Ra has a higher value than the one generally accepted, $3{\cdot}48 \times 10^{-4}(\text{year})^{-1}$. Neither of them, however, can claim a very high degree of accuracy for reasons given in the paper. The objections raised in the case of uranite and clevite do not apply in the case of bröggerite—a mineral which is one of the oldest uranites, and particularly free from all alteration products.

The results obtained for the most carefully prepared solutions are :—(*a*) The disintegration constant of radium has a value of $4{\cdot}22 \times 10^{-4}(\text{year})^{-1}$, and $4{\cdot}14 \times 10^{-4}(\text{year})^{-1}$. (*b*) The half-value period of Ra indicated is accordingly 1642 years and 1674 years. The result agrees very closely with the value found by Rutherford [Abs. 180 (1915)]. A. B. W.

332. *Distribution of Transmitted and Reflected β-Particles.* **A. F. Kovarik** and **L. W. McKeehan.** (Phys. Rev. 6. pp. 426–436, Dec., 1915.)—It is shown that the statistical (or counting) method of determination used by Geiger (Manchester Lit. and Phil. Soc., Proc. 55. p. 20, 1911) is quite satisfactory for accurate work on β-radiations, with proper methods of experimenting and checks upon the results. The authors have applied the method to the simultaneous determination of the distribution of the β-particles from RaD, E, F, transmitted and reflected by a plate of Al of medium thickness. These results, with those given in a previous paper [Abs. 1269 (1914)], have been interpreted in accordance with Rutherford's theory of single scattering [Abs. 1347 (1911)]. The rays from a thick radiating plate emerge on the

transmission side in a manner similar to the emission of light from a heated solid, *i.e.* according to a cosine law. From the phenomenon of initial scattering described in a former paper (*loc. cit.*) the authors have deduced that the mean free path between deflections in Al is of the order of $10^{-8}$ cm.
A. B. W.

333. *Absorption of β-Particles by Air and $CO_2$.* **A. F. Kovarik.** (Phys. Rev. 6. pp. 419–425, Dec., 1915.)—A method depending on the change of pressure of a gas has been devised for measuring the absorption of β-particles. This method consists of measuring the ionisation in a shallow ionisation chamber placed at a fixed distance from a source of radiation within a high-pressure vessel: reducing the ionisation readings at various pressures to that at 1 atmo., measuring graphically the mean path of the β-particles, and then, in the usual manner, deducing the coefficient of absorption. It is found that the absorption curves in gases are the same in shape as those obtained with Al-foils. The following tabulated results give the absorption coefficients in air and $CO_2$ for the β-particles emitted from various radioactive substances:—

| Source of β-particles. | $Cm.^{-1}$ air. 1 atmo. and 22° C. | Air. $(Cm./cm.^2)^{-1}$. | $Cm.^{-1}$ $CO_2$. 1 atmo. and 22° C. | $CO_2$. $(Cm./cm.^2)^{-1}$. |
|---|---|---|---|---|
| Radium E .................... | 0·0152 | 12·70 | 0·0297 | 16·31 |
| Actinium C + D .......... | 0·0091 | 7·60 | 0·0175 | 9·62 |
| Thorium C + D............ | 0·0068 | 5·68 | 0·0129 | 7·08 |
| Uranium $X_2$ ............... | 0·0065 | 5·43 | 0·0114 | 6·26 |
| Uranium $X_1$ ............... | 0·12 | 100 | 0·23 | 126 |
| Radium D .................. | 0·097 | 81 | 0·188 | 101 |
| Radium D (very soft) ... | 0·64 | 535 | 1·69 | 930 |
| Thorium B.................. | 0·090 | 75 | 0·142 | 78 |
| Actinium B................. | 0·31 | 260 | — | — |

The relations between the ionisations of the soft and hard radiations were computed by extrapolation to zero absorber. This was done for the two soft radiations of RaD compared with the effect of the radiations of RaE (ratio 0·8 for more penetrating β-rays, 2·4 for very soft rays); soft and hard rays of the actinium active deposit (ratio 1·14); soft and hard rays of the thorium active deposit (ratio 2·86); soft and hard rays of UrX.
A. B. W.

334. *Structure of γ-Rays.* **J. Kunz.** (Phys. Rev. 6. pp. 418–418, Dec., 1915.)—A mathematical discussion of the structure of the γ-rays on the basis of the electromagnetic theory of light in which the endeavour is made to visualise the process of the modification of the electric field as the electron is retarded, stopped, and returned on collision. The article is illustrated with diagrams of these lines at various epochs. [See Abs. 1507 (1914).]
E. H. B.

335. *Relation between Atomic Weights and Radio-active Constants.* **F. G. Carruthers.** (Nature, 96. pp. 565–566, Jan. 20, 1916.)—Plotting the values of "log. range" and "log. atomic weight" for all the radio-elements emitting α-particles, it appears that each group of isotopes gives a straight line, and the lines for the various groups are approximately parallel and equally spaced. From these relations it is deduced that the range of the α-particle is universally proportional to about the 21st power of the atomic weight

of the element emitting it. The groups, arranged in the fashion indicated above, follow one another in a rational order. The above relationships were detected as a result of noticing first the evident family resemblance between the $\gamma$-rays in the isotopic groups. Among the $\beta$-rays something of the same sort is noticeable, "$\mu$" generally falling with increasing atomic weight, but for the very soft $\beta$-rays $\mu$ is directly proportional to the 33rd power of atomic weight. A. B. W.

336. *Reflection of Slow-moving Electrons by Copper.* **A. W. Hull.** (Phys. Rev. 7. pp. 1–17, Jan., 1916.)—It is shown that the electron reflection from a copper surface roughened by prolonged heating at 350° C. is, like that of electrolytic silver, very small, being only 10 % for electrons having a velocity of 0·4 volt. This is explained by the ultramicroscopic roughness of these surfaces. Such surfaces, according to the views advanced by the author, should make excellent electric "black-bodies" for receiving electron currents.

The scattering of a beam of slow-moving electrons has been shown to be due to deflection by strong electric fields, and multiple reflection between the plate and its surroundings, rather than to gas molecules or mutual repulsion of the electrons.

$\delta$-Rays have been produced by mercury ions which have fallen through only 12·4 volts. The energy of the fastest of these $\delta$-rays is approximately the same as that of the ions, suggesting that the energy-exchanges between ion and electron are governed by quantum relations. A. B. W.

337. *Radio-active Deposit from the Atmosphere on an Uncharged Wire.* **S. J. M. Allen.** (Phys. Rev. 7. pp. 133–138, Jan., 1916.)—The author has previously found that a considerable amount of active deposit was obtained in a smoky atmosphere on an uncharged wire [see Abs. 1440 (1908)]. Recent experiments have confirmed this result. The action seems to be that negatively charged nuclei consisting of smoke or dust particles collect radio-active matter which is positively charged, and then by diffusion, or the action of wind, are drawn to the uncharged wire. Such deposit was obtained by the author whether the wire was insulated or earthed. As the deposit found is of small amount a long wire (360 ft.) was employed in conjunction with a sensitive electrometer. The experiments extended over 14 months. The duration of exposure of the wire ranged from 15 hours upwards. It was found from a study of the decay curves of the active deposit that this consisted of a mixture of the various disintegration products of radium, and that these products were present in widely different proportions on different occasions. No definite evidence was found of thorium products among those collected. This was in sharp contrast with the results obtained previously with a *charged* wire, when these products were sometimes present in proportions as great as 30–40 %. In general it was found that when a large amount of soot collected on the wire there was also a large active deposit, though there were exceptions to this rule. The effect of rain was pronounced. A heavy continued rain always cleared the air of the activity. J. S. Di.

# HEAT.

338. *Heat Conductivity of Tungsten Filaments.* **I. Langmuir.** (Phys. Rev. 7. pp. 151–152, Jan., 1916. Abstract of paper read before the Am. Phys. Soc., Oct. 30, 1915.)—From previous work [see Abs. 322 (1916)] the resistance of a tungsten filament over the range 600° to 2800° C. is found to be expressed quite accurately by the equation $R - cT^{\rho}$, where $c$ is a constant and $\rho = 1{\cdot}24$. Similarly the watts radiated can be expressed as $W = cT^{w}$ where $w$ is found to be 4·96. If the heat conductivity ($\lambda$) of tungsten is assumed independent of temperature, then the equation for the distribution of temperature along the filament near a cooling junction is $a^2(d^2\theta/dx^2) + \theta^{\rho} = \theta^{w}$, where $\theta$ is the ratio of the temperature (° K.) at the point $x$, to that (T) at a point far removed from the cooling junction, while $a\,(V/l) = \sqrt{(R\lambda T)}$, where R is the resistance of the filament at temperature T, and $V/l$ is the potential gradient along the central part of the filament. Tables of $\theta$ in terms of $x/a$ are being prepared. Calculation by means of this equation from Worthing's data on the heat conductivity of tungsten at high temperatures [see Abs. 818 (1915)] gives $\lambda = 1{\cdot}14$ watts/cm./degree at a temperature of 2410° K. It is found that tungsten fits in as well as most other pure metals with the Lorenz law that $\lambda R/T$ is constant for all metals at all temperatures. J. W. T. W.

339. *A Method of measuring Heat Conductivities.* **R. W. King.** (Phys. Rev. 6. pp. 437–445, Dec., 1915.)—A new method is described which can be used for the measurement of thermal conductivities through a wide range of temperature and conductivity. [See Abs. 1695 (1915).] The method bears a certain resemblance to those of Ångström and Neumann, and, in some of its experimental features, to that of Barratt [Abs. 1991 (1914)]. Periodic waves of heat are propagated along a wire 2·5 mm. in diam., and it is shown that $k$, the quotient of thermal conductivity by the product of density and specific heat, is connected with the velocity, $v$, of propagation of the heat wave, and the period, T, of the heat wave, by the relation

$$k = \frac{1}{4\pi}\left(\frac{T_1^2 T_2^2 v_1^2 v_2^2 (v_1^2 - v_2^2)}{T_2^2 v_2^2 - T_1^2 v_1^2}\right)^{1/2},$$

the experiments being done in pairs while maintaining a constant value in each pair of the rate of loss of heat from the wire. Results are given for the metals copper and tin, and in the case of the former the conductivity shows a temperature coefficient of −0·00022 between 35° and 60° C., agreeing with the determinations of Jaeger and Diesselhorst for one of their specimens. Experiments are proceeding at higher and lower temperatures and in a magnetic field. T. B.

340. *Thermal Conductivity and Viscosity of Gases.* **J. A. Pollock.** (Phil. Mag. 31. pp. 52–54, Jan., 1916. Paper read before the Roy. Soc. of N.S. Wales.)—In the equation $k = f\eta c_v$, expressing the thermal conductivity of a gas in terms of the viscosity and specific heat, the coefficient $f$ is a numerical factor which is approximately constant for gases of the same atomicity. Such a fact suggests the probability of a relationship between

$f$ and $\gamma$, the ratio of specific heats. But long before the result just mentioned was fully established, the probability of $f$ being a function of $\gamma$ was recognised, though it was not generally appreciated. As early as 1876 Boltzmann, from theoretical considerations, obtained the expression $f=3f'(\gamma-1)/2$, where $f'$ is the constant for monatomic gases. It has been known for some time that the equation is physically inaccurate.

Recently new results for the thermal conductivities of a number of gases have been published by Eucken. In connection with these, Eucken discusses the dependence of $f$ on the properties of the molecule and on temperature also. He did not, however, consider the relationship of $f$ to $\gamma$, but, from the zero-temperature values of the thermal conductivities and viscosities given by him, a relation appears to exist between the two factors which can be expressed by an equation of the form $f=a(\gamma-1)/\gamma^n$, where $a$ and $n$ are constants. With provisional approximation this may be written $f=7{\cdot}32(\gamma-1)/\gamma^{1{\cdot}3}$. This formula shows fair agreement with experimental results for argon, hydrogen, nitrogen, oxygen, and $CO_2$. [See Abs. 636 (1912) and 1301 (1913).] E. H. B.

**341.** *On the Cooling of Cylinders in a Stream of Air.* **J. A. Hughes.** (Phil. Mag. 31. pp. 118–130, Feb., 1916.)—Experiments were made on the loss of heat from cylinders and a tube of stream-line section when maintained at 100° C. and exposed to air currents of different velocities. The tube under test was placed across the middle of a square channel of 3 ft. side and 10 ft. long through which air was drawn by a fan, the *average* wind velocity being obtained from experiments with a Pitot tube and gauge. Steam was passed through the tube and the heat lost estimated from the weight of steam condensed when the steady state had been attained. Five cylindric tubes were experimented on, their diams. ranging from 0·48 to 15·5 cm., while the wind velocity varied from 2 to 14 m. per sec. The results showed (*a*) that at all velocities H, the loss of heat per cm. length, was proportional to $d^{0{\cdot}67}$; (*b*) that at different speeds H is proportional to $v^n$, where $n$ increases from 0·55 for the smallest cylinder to 0·98 for the largest. This brings into agreement the results obtained by previous workers who had found $n=1$ for large bodies [*e.g.* Reynolds] and $n=0{\cdot}5$ for wires [Abs. 1998 (1914)]. If, however, the velocity was low, $n$ appeared to be smaller, about 0·6.

The stream-line tube had a perimeter of 23·1 cm. and a max. thickness of 2 cm. H was found to be slightly greater than for a circular tube of the same total area and very much greater than for a tube of the same (max.) thickness or air-resistance. The loss, too, was greater when the blunt end faced the wind. D. O. W.

**342.** *Simple Demonstration of the Reduced Vapour-pressure over a Solution.* **A. T. Jones.** (Science, 43. p. 73, Jan. 14, 1916.)—Two crystallising dishes about 5 cm. in diam., half filled with water and with a solution of sodium chloride (1 gm. salt to 5 gm. of water) respectively, were placed under a bell-jar. The latter rested on a plate of glass and the junction was made air-tight by means of vacuum wax. After standing in a room at the ordinary temperature from Jan. to March, the surface of the solution stood about 9 mm. higher than that of the water, although at the commencement the two levels were about the same. A. F.

**343.** *Reaction between Gas and Pole in the Electrical Ignition of Gaseous Mixtures.* **W. M. Thornton.** (Roy. Soc., Proc. 92. pp. 9–22, Oct. 1, 1915.)—With mixtures of ethane or CO with air, the ease of ignition at atmospheric pressure by d.c. break-sparks varies with the metal of the poles, increasing in the order Pt, Cu, Ni, Fe, Al; with CO-air mixtures rich in CO, Cu and Pt change places. When alternating current is used, the order is Cu, Fe, Ni, Al, Pt. For the mixtures containing 7 % of ethane or 42·5 % of CO, the igniting currents in amps. are as follows :—

| Metal. | Continuous Current, 100 volts. | | Alternating Current, 200 volts, 40 ∿. | |
|---|---|---|---|---|
| | Ethane, 7 %. | CO, 42·5 %. | Ethane, 7 %. | CO, 42·5 %. |
| Pt | 1·98 | 0·90 | 2·5 | 2·6 |
| Cu | 1·65 | 1·10 | 9·7 | 9·7 |
| Ni | 1·47 | 1·05 | 8·7 | 4·7 |
| Fe | 1·33 | 0·85 | 7·5 | 7·5 |
| Al | 1·15 | 0·82 | 2·9 | 3·2 |

Experiments were also made with jump-sparks, *i.e.* the single disruptive discharge through a gas from condensers or from the secondary of an induction coil, the primary circuit of which is made or broken with the trembler locked; in this case only mixtures of coal-gas and air were examined. With jump-sparks, the ease of ignition with different poles increases in the order Ni, Fe, Al, Pt, Cu, and with condenser break-sparks in the order Cu, Fe, Ni, Al, Pt.

From these results it is concluded that the order of difficulty of ignition by d.c. break-sparks is that of the density of the poles; that by alternating or condenser discharge sparks it is proportional to the rate of heating of the points of contact, and that by jump or long disruptive discharge sparks it varies with the tenacity of the material of the poles. With carbon poles, condenser discharge in coal-gas has most effect upon the hydrogen, longer disruptive discharge upon the methane. T. H. P.

**344.** *Heats of Neutralisation and the Theory of Quanta.* **A. Heydweiller.** (Ann. d. Physik, 48. 5. pp. 681–692, Nov. 30, 1915.)—Among the valuable relationships between optical and thermal constants which Planck's quanta theory has supplied is one between the thermal change attending chemical transformations and the accompanying alteration in optical properties, which may be explained on the electron theory by change in the electronic oscillation periods. Researches on the electronic optics of water ions have led the author to opine that in ionic reactions, especially where electrolytic disintegration of molecules or ionic combinations take place, the optical changes attending the same may be completely traced to the change in oscillation period of the valency electrons. Haber had first directed attention to this subject, but his work on heats of formation and transformation of salts had been carried out with substances in the solid state. Although simpler relationships occur in solution, yet the necessary experimental support has not been forthcoming. The author here attempts to remedy this defect. For establishing the theoretical standpoint, the heat of union of the ions H and OH is especially suitable since as heat of neutralisation it has been very accurately measured, while, in contrast to the heats of combination of most inorganic ions, it possesses a magnitude which leads us to anticipate a not inconsiderable change in electronic frequency, thereby allowing of more exact measurement. Finally, especially exact observations can be made on the optical properties of fluid water for estimating the oscillation-number of electrons in the water molecule. The paper contains a theoretical discussion of the various points raised. It was necessary to determine afresh the various constants for ionic refraction, such as density, refraction, and electric conductivity of alkali hydroxide solutions of different aqueous concentrations, on account of former results being too meagre for the purpose required. The hydroxides of Li, Na, K, and Rb at 6 to 8 different concentrations were employed. Full experimental details are given supplemented by tables of results. Agreement was obtained as anticipated, but the author points out difficulties which would attend an extension of the experiments to other substances. H. H. Ho.

**345.** *A Criticism on van der Waals' Equation and some New Equations derived therefrom.* **J. Kam.** (Phil. Mag. 31. pp. 22–36, Jan., 1916.)—In this paper the author takes for granted that the factors "$a$" and "$b$" of van der Waals' equation have the following effects: "$a$" of diminishing the gas-pressure towards the exterior with a value $P_I = a/V^2$, the "Inward Pressure"; "$b$" of increasing that pressure at the rate $V/(V-b)$. Two separate factors $b$ and $\beta$ are used in place of van der Waals' factor "$b$," where $b$ is the volume of N molecules filling a volume $\phi = (V+b)$ at a pressure $\pi = RT/V$, and $\beta$ the volume of $N_1$ mols. filling the volume V at the same temperature and pressure. Consequently $b$ is a constant, $\beta$ a variable; for the smaller V is (*i.e.* the greater the compression), the less the number of molecules required to exert a pressure $\pi = RT/V$. Hence the inverse value of V at any pressure $\pi = RT/V$, is not the density $1/V$, but the density $1/(V+b)$, which as "$b$" is a constant increases less rapidly than the volume V decreases. For small values of V these factors deviate considerably. The criticism is then based upon this standpoint and a number of interesting deductions are made. For example, the density at the critical state is for all substances 2/3 of the theoretical density. The gaseous laws again hold good for the critical state. The critical "Inward Pressure" and critical pressure are equal, a deduction confirmed by two independent methods, and a natural consequence should be the disappearance of surface tension and latent heat of vaporisation at the critical point, since the cohesive forces would be compensated by the thermic pressure.

The whole subject is treated in great detail. H. H. Ho.

**346.** *Planck's Radiation Formula deduced from Hypotheses suggested by X-ray Phenomena.* **W. Duane.** (Phys. Rev. 7. pp. 143–147, Jan., 1916. Abstract of paper read before the Amer. Phys. Soc., Oct. 30, 1915.)—From general observations on X-ray investigations the author is led to the general conception that radiation of all frequencies is produced by the bombardment of atoms by electrons. A discussion is given on the distribution of energy in the spectrum of black-body radiation at constant temperature on the following fundamental assumption: Some of the electrons in a radiating body fly about more or less freely, hitting the atoms and thereby producing the radiation; and the number $dN$ of these electrons per cm.$^3$ that have speeds lying between $v$ and $v+dv$ is given by Maxwell's distribution law, viz., $dN = Ae^{-v^2/\alpha^2}v^2dv$, where A is a constant at a given temperature, and $\alpha$, the most probable velocity, is connected with the mass of an electron and the temperature T by the equation $\frac{1}{2}m\alpha^2 = kT$, $k$ being the well-known constant.

The following hypotheses are now put forward: (1) When an electron produces radiation by hitting an atom, the frequency $\nu$ of the radiation is given by the equation, Energy $= \frac{1}{2}mv^2 = h\nu$. (2) When electrons of speed $v$ produce X-rays by hitting atoms, the energy radiated per hit is proportional to the fourth power of the speed; that is, it is equal to $= lv^4$, $l$ being a constant.

Using the above relations Wien's equation ($dE = Ce^{-h\nu/kT}\nu^3 d\nu$) is deduced. Extending the "frequency hypothesis" [No. (1) above] to Energy $= \frac{1}{2}mv^2 = nh\nu$ (where $n$ may be any positive integer); and the "energy hypothesis" to Energy radiated per hit $= lv/n^4$, Planck's equation $\left(dE = C\frac{\nu^3 d\nu}{e^{h\nu/kT} - 1}\right)$ is at once obtained. The discussion in the paper applied to the general radiation and *not* to the characteristic radiation. A. B. W.

**347.** *Quantum Hypothesis for Molecules with Several Degrees of Freedom.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 17. 22. pp. 407–418, Nov. 30, 1915.)—Beginning with the well-known fundamental relations $dS/dU = 1/T$ and $S = k \log_e W$, the author proceeds to introduce the possibility of a rigid molecule rotating about a fixed axis for which its moment of inertia is J. It is then shown that the mean energy in the $n$th elementary region is given by $u_n = (h^2/8\pi^2 J)/(n^2 + n + 1/2)$, and that the thermodynamic function $\psi$ in the stationary state is expressed by $\psi = Nk \log_e \Sigma_0^\infty (2n+1)e^{-(n^2+n+1/2)\sigma}$, where $\sigma = h^2 \div (8\pi^2 JkT)$. E. H. B.

**348.** *Quantum Hypothesis for Molecules with Several Degrees of Freedom.* II. **M. Planck.** (Deutsch. Phys. Gesell., Verh. 17. 24. pp. 438–451, Dec. 31, 1915.)—In this second and concluding paper [see preceding Abs.] the author discusses in considerable detail the general case, the results being embodied in 70 equations, some being very complicated. Cases of special note are presented at the close for the energy at extreme low temperatures. Thus the zero-point energy for oscillators with three degrees of freedom is found to be $U = Nh\omega/2\pi \cdot 5/3$, which is not 3 times but $3\frac{1}{3}$ times that of the rectilinear oscillator; whereas the zero-point energy for plane oscillators is shown to be just 3 times that for rectilinear ones. [See preceding Abs.] E. H. B.

**349.** *Entropy Constants of Diatomic Gases.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 17. 22. pp. 418–419, Nov. 30, 1915.)—A mathematical discussion on the above subject in reply to Tetrode. [See Abs. 1292 (1915).] E. H. B.

**350.** *Quantum Hypothesis.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 318–327, Dec., 1915.)—A mathematical discussion of the fundamental theorem of the quantum theory in reply to a paper by M. Wolfke. [See Abs. 1192 (1915), and 97 (1916).] E. H. B.

**351.** *Quantum of Action.* **W. Wilson.** (Phil. Mag. 31. pp. 156–162, Feb., 1916.)—A comparison of the author's form of the quantum hypothesis and that adopted by J. Ishiwara. [See Abs. 878 (1915) and preceding Abs.] E. H. B.

## SOUND.

352. *Discontinuous Wave Motion.* **C. V. Raman** and **S. Appaswamaiyar.** (Phil. Mag. 31. pp. 47–51, Jan., 1916.)—An analytical discussion of the principal mode of vibration of a bowed string as ascertained from the form of its vibration curves, leads to the result that at two epochs in each period of vibration the string should pass as a whole through its position of statical equilibrium, alternately in opposite directions. At the first epoch, according to the analysis, the velocity at every point on the string is proportional to its distance from one end, there being *a discontinuous fall of the velocity to zero* at the other end. At the second epoch the state of matters is reversed, the motion being such that the velocities are proportional to the distances from the farther end, the discontinuous fall being at the nearer end. These results are of importance as defining the essentially discontinuous nature of the motion involved, but it is noticed from the literature of the subject that they are obtained by an elaborate and indirect analytical process from the observed form of the vibration-curves, and had not previously received direct experimental confirmation. This is now given in the following way.

The mode of vibration of the string is evidently determined by its configuration and its velocities at either of the two epochs referred to above. If, therefore, it is possible directly to impose at every point of a finite string in its position of equilibrium the initial distribution of velocities with a discontinuity at one end as indicated by the analysis, the resulting free oscillations should have the same characteristic vibration curves as a bowed string. It was found possible successfully to realise these conditions in an experiment by arranging that a stretched string has initially a uniform angular velocity about one end, and that in the course of this motion one point on it impinges upon and is suddenly brought to rest by a fixed stop or bridge provided for the purpose. The length of string between the fixed end and the bridge is thus isolated, and photographic records of the vibration-curves secured in the usual way entirely confirmed the analysis. E. H. B.

353. *Propagation of Sound in Narrow Tubes of Variable Section.* **Rayleigh.** (Phil. Mag. 31. pp. 89–96, Feb., 1916.)—Under this head there are two opposite extreme cases fairly amenable to analytical treatment, namely : (1) when the changes of section are so slow that but little alteration occurs within a wave-length of the sound propagated, and (2) when any change that may occur is complete within a distance small in comparison with a wave-length.

The analytical solution of the first case (to a certain degree of approximation) shows that the reflection, if any, is at most of the second order of smallness, and that the intensity of the transmitted sound equals that of the incident sound if the tube recovers its original diameter. The *phase* of the transmitted sound shows rather unexpectedly a linear *acceleration*.

The second problem, dealt with to a certain degree of approximation, yields Poisson's formulæ $B/A = (\sigma_1 - \sigma_2)/(\sigma_1 + \sigma_2)$, $C/A = 2\sigma_1/(\sigma_1 + \sigma_2)$, in which A, B, and C are the amplitudes of the incident, reflected and transmitted sounds, and $\sigma_1$, $\sigma_2$ are the sections of the tubes before and after the change. A still closer approximation is then made which modifies the above formulæ, the chief effects, however, being upon the phases of the reflected and transmitted waves. E. H. B.

354. *Transmission, Reflection, and Absorption of Sound by Different Materials.* **F. R. Watson.** (Phys. Rev. 7. pp. 125–132, Jan., 1916.)—In this experimental work the source of sound was an adjustable whistle blown by air from a constant-pressure tank and mounted at the focus of a parabolic reflector of 5 ft. aperture and 9 in. focal length. The receiver of sound, a Rayleigh resonator, was mounted on the far side of the sound obstacle for testing its transmission or on the near side for reflection. It was found that the transmission of sound of constant pitch depends on at least three qualities of the material—its porosity, density, and elasticity. A barrier of paper-lined hair-felt showed reflections and transmissions which are fluctuating functions of the thickness in use, somewhat like the interference of light at thin plates. E. H. B.

355. *Sound Measurement.* **H. Zwaardemaker.** (K. Akad. Amsterdam, Proc. 18. pp. 165–170, Sept. 8, 1915.)—The author describes the measurement of the intensities of sounds by various forms of the Rayleigh disc. In earlier work the disc or mirror was set in the required oblique position by a magnetic control. But this has been replaced by a bifilar suspension, and finally by a long Wollaston fibre, flattened or not. [See Abs. 1128 (1908).] E. H. B.

356. *Resonance of Sonorous Bodies.* **G. Sizes.** (Comptes Rendus, 161. pp. 781–784, Dec. 20, 1915.)—In the present paper, the very large array of inferior and superior harmonics previously recognised by the author are classified into three groups. These form the general scale, the partial medial scale, and the partial scale of the predominant sound. E. H. B.

357. *Theory of Helmholtz Resonator.* **Rayleigh.** (Roy. Soc., Proc. 92. pp. 265–275, Feb. 1, 1916.)—An analytical treatment using the appropriate spherical (Legendre's) functions. It was hoped that this would give a closer approximation than the previous treatment and also prove easier to follow. The results differ slightly from those given in the author's "Theory of Sound," § 311. E. H. B.

358. *After-sounds.* **F. Roels.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 311–319, 1916.)—Gives the results of a series of tests as to *after-sounds* heard in the special silence camera after a variety of different stimuli from Galton and Edelmann whistles. These after-sounds are plainest for a duration of 2 to 30 secs., and are higher in pitch than that of the stimulus. Another interval of 2 to 30 secs. is often filled by a second after-sound lower than the first, and mostly of longer duration. E. H. B.

# ELECTRICITY AND MAGNETISM.

## THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

359. *Electromagnetic Units.* **M. Ascoli.** (Elettrotecnica, 2. pp. 781-789, Nov. 25, 1915.)—Confusion arises under any L.M.T. system of units; we need at least five fundamental quantities. Of those which appear in the fundamental equations any five may be chosen. If we attend to this we, for instance, avoid the error of supposing that magnetic field and magnetic induction (in e.-m. measure) are capable of being measured in the same units. According to the particular pentad chosen so would be the resultant dimensions of particular quantities; but the resultant systems would not be in any sense out of harmony with one another. The distinction between numerical equations and equations of relation has to be kept in view. Illustrations are given from dynamics as well as from electro-magnetism.

A. D.

360. *Conduction of Electricity through Metals.* **J. J. Thomson.** (Inst. of Metals, J. 14. pp. 3-20, 1915. Nature, 96. pp. 494-499, Dec. 30, 1915. Abstract.)—[See Abs. 1085 (1915).]

361. *Electric Potential Gradient of the Atmosphere at Rio de Janeiro.* **H. Morize.** (Terrest. Magn. 20. pp. 175-186, Dec., 1915.)—Describes the instrument which has been in use since 1909 for obtaining relative values of potential gradient. It consists of an Armet de Lisle radio-active disc in conjunction with a Benndorf electrometer. Owing to the high degree of atmospheric humidity special difficulties were experienced with the insulation and special precautions, which are described in the paper, had to be taken to mitigate them. It has not yet been found possible to obtain absolute values of the potential gradient. Tables are given of mean hourly values for each quarter of the year from Sept. 1910, to Aug. 1914, computed from the records of "calm" days only, and harmonic coefficients for the diurnal variation are also given. The chief characteristics of the diurnal variation are, a marked minimum between 2 a.m. and 3 a.m., and a maximum, less marked, between 10 a.m. and noon.

R. C.

## DISCHARGE AND OSCILLATIONS.

362. *Relations of Photo-potentials of Different Metals when stimulated by Light of a Given Frequency.* **A. E. Hennings** and **W. H. Kadesch.** (Phys. Rev. 7. pp. 147-148, Jan., 1916. Abstract of paper read before the Am. Phys. Soc., Oct. 30, 1915.)—The six metals, Mg, Al, Sn, Cu, Fe, and Zn, have been studied, a spectral line from a mercury arc being the particular frequency employed. The curves relating p.d. with photo-current indicate the existence of a max. velocity of emission. For a given frequency, the curves for the different metals, freshly scraped, all meet the voltage axis at very nearly the same point. When the surfaces were allowed to "age" there was a gradual fall in the max. velocities of the electrons. This is attributed to the formation of surface films.

A. B. W.

**363.** *Value of "h" determined Photo-electrically from the Ordinary Metals.* **W. H. Kadesch** and **A. E. Hennings.** (Phys. Rev. 7. p. 147, Jan., 1916. Abstract of paper read before the Am. Phys. Soc., Oct., 1915.)—In photoelectric observations of Mg, Al, Sn, Cu, Fe, and Zn freshly made *in vacuo*, it was found that the applied potential necessary to prevent the escape of electrons was, within the limits of experimental error, almost the same, for a given frequency, for all the metals tested. Because of the greater range of frequencies to which they are sensitive, Mg and Al were chosen for more careful study. The value of "*h*" obtained from Mg was $6{\cdot}45 \times 10^{-27}$; that from Al, $6{\cdot}41 \times 10^{-27}$. A. B. W.

**364.** *Complete Photoelectric Emission.* **O. W. Richardson.** (Phil. Mag. 31. pp. 149–155, Feb., 1916. Part of an address delivered before the British Assoc. at Manchester, Sept., 1915.)—It is well known that when light of sufficiently short wave-length is allowed to fall on metals, an emission of electrons takes place under its influence. Since all substances emit light when they are raised to a high temperature, an emission of electrons from hot bodies owing to the action of light will occur even when they are not illuminated from an external source. The emission of electrons which arises in this way may conveniently be termed the "complete photoelectric emission," to indicate that it is excited by the complete (black-body) radiation with which the material is in equibrium at the temperature under consideration. It is of interest to inquire whether this emission will resemble in its behaviour the thermionic effects which have been investigated experimentally and to seek to determine how its magnitude compares with that of the observed thermionic emission. The most striking property of the thermionic emission of electrons is that expressed by the current-temperature relation $i = AT^{\lambda}\epsilon^{-b/T}$ ... (1), in which $i$ is the max. current per unit area, $T$ = absolute temperature, $A$, $\lambda$, and $b$ are constants. The author has shown [Abs. 1897 (1912)] that it follows from simple thermodynamic considerations that the complete photoelectric emission is also governed by an equation of type (1). The thermodynamical argument does not determine the numerical value of the constants A and $b$ ($\lambda$ is unimportant) which enter into the formula for the complete photoelectric emission. It does, however, determine the meaning of $b$, which is closely related to the work done by an electron in escaping from the metal. The values of the minimum frequency of the light which is able to excite a photoelectric emission from metals show that $b$ is not very different in the case of photoelectric and thermionic emissions from a given material. It is not certain that the values of $b$ for the two effects are not identical for the same substance. The value of A, on the other hand, is left entirely arbitrary by the thermodynamic considerations, which do not therefore enable us to determine the scale of magnitude of the complete photoelectric emission. Thus the theoretical argument leads to the conclusion that the complete photoelectric emission varies with temperature in the same general manner as do the observed thermionic effects; it is possible, although not certain, that the indices $\lambda$ and $b$ are identical in the two cases contrasted, in which case the two emissions would be in the same relative proportions at all temperatures; on the other hand, the absolute value of the complete photoelectric emission is left entirely undetermined, so that we are unable to determine by such calculations what proportion it bears to the observed thermionic emission.

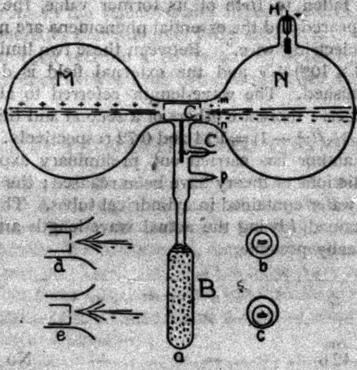
This information can, however, be obtained from known photoelectric data in the case of Pt. The smallest thermionic currents from Pt ever recorded in the neighbourhood of 2000° K. are those observed by H. A. Wilson [Abs. 145 (1904)]. But even in this extreme case the observed thermionic current is about 5000 times as large as the complete photoelectric current.

E. H. B.

365. *Carbon Consumption in Electric Arc.* **W. G. Duffield** and [Miss] **M. D. Waller.** (Roy. Soc., Proc. 92. pp. 247–252, Feb. 1, 1916.)—A continuation of previous work [see Abs. 100 (1916)] in which the importance of a hot kathode was demonstrated. It was suspected that the anode consumption of carbon was unimportant, and this was tested by using as anode the side of a carbon rotating at 750 revs. It is found that the loss from the rotating anode is much less than that from the kathode, and it therefore appears that the anode loss of carbon is unimportant in the mechanism of the arc, and that the main function of the anode is to receive the carriers of the current produced by the essential process occurring at the surface of the kathode.

J. W. T. W.

366. *Tube for showing Colour Effects of Positive and of Kathode Rays in Residual Air, Hydrogen, Helium, etc.* **C. T. Knipp.** (Science, 42. pp. 942–943, Dec. 31, 1915.)—Positive rays have their origin in front of the kathode, and under the action of the electric force fall toward it. J. J. Thomson has shown that most beautiful and striking colour effects may be had by using hollow kathodes in specially designed tubes containing each a trace of some inert gas such as helium, argon, or neon [see Abs. 1862 (1913)]. The general design of the tubes that J. Kunz and the author have found best suited is shown in the accompanying Fig.



The discharge tube is dumb-bell shaped. It is made of two 1-litre Florence flasks, M and N. The hollow cylindrical kathode C is mounted in the neck while the anode A is placed in one of the bulbs. The kathode terminal C, the nipple *p* for exhausting, and the charcoal bulb B are all attached to one vertical tube as shown. The process of filling the discharge tube, sealing it off from the pump, and its subsequent use are described in detail. The most interesting phenomenon is the colour of the two beams. The kathode beam in helium is a greenish grey colour, while the positive-ray beam in the same gas is a beautiful red. The red due to the positive ions is so persistent that it appears at the very origin of these rays—at the edge of the Crookes dark space in front of the kathode (shown by the dotted line *mn* in the Fig.). The best results are obtained only when the hollow kathode C, which is an Al cylinder closed at the ends with Al discs, is placed exactly on the axis of the tube connecting the bulbs M and N. Through the centre of each disc is cut a small rectangular opening. The correct position is shown in the Fig., end view at *b*, and side view at *d*. **A. E. G.**

**367.** *Electric Waves along Insulating "Wires."* **H. Zahn.** (Phys. Zeits. 16. pp. 414–416, Nov. 15, 1915.)—In a theoretical investigation D. Hondros and P. Debye showed that under certain conditions electromagnetic waves might be propagated along "wires" of dielectric or insulating material in a similar way to that in which they pass along wires of conducting material. The simplifying assumption was made that the dielectric in question was perfect, *i.e.* was free from absorption and characterised solely by its index of refraction $\nu$. Further, these dielectric "wires" were supposed to be of infinite length.

With these idealisations it was found that electric waves could be propagated along a dielectric "wire" of radius $\rho$ only if between the wave-length $l$ (in vacuum) and the quantities $\rho$ and $\nu$, the following relation held: $l \leqq 2{\cdot}61\,\rho\sqrt{(\nu^2-1)}$. In the limiting case of equality, these "dielectric waves" behave very much like the waves along metallic wires. Their velocity of propagation $v$ along the "wire" is equal to that in vacuum, and the electric lines of the external field stand almost normally to the surface of the "wire." If, on the other hand, $l$ is small compared with the expression on the right, then the state of things is essentially different. The speed of propagation has fallen to $1/\nu$th of its former value, the external field has practically disappeared and the essential phenomena are now confined to the interior of the dielectric "wire." Between these two limiting cases we have $3\times10^{10} > v > (3\times10^{10}) \div \nu$ and the external field is deviated and correspondingly diminished. The wave-length referred to above is the fundamental and strongest; there are others of a second and third order for which the values of $l/\rho\,.\,1/\sqrt{(\nu^2-1)} = 1{\cdot}14$ and $0{\cdot}72$ respectively.

The present author has carried out preliminary experiments in which some of the predictions of theory have been realised; the dielectric "wires" were of distilled water contained in cylindrical tubes. The table shows some of the results obtained, $l$ being the actual wave-length attempted and $l_1$ the greatest theoretically possible.

| $\rho$. | $l_1$. | $l$. | $v \times 10^{-10}$. | Remarks. |
|---|---|---|---|---|
| cm.<br>0·54 | cm.<br>12·6 | — | — | No certain waves |
| 0·71 | 16·6 | cm.<br>about 28 | 2·95 | Very bad waves |
| 1·00 | 28·4 | 27·9 | 2·94 | Good waves |
| 1·25 | 29·8 | 26·0 | 2·75 | " " |
| 1·53 | 35·8 | 24·4 | 2·58 | " " |
| 1·90 | 44·5 | <24 | <2·58 | Waves yet discernible |
| 2·05 | 48·0 | — | — | No waves |

[See Abs. 1132 (1910).] **E. H. B.**

**368.** *Wave-length of Electrical Vibration along a Thin Straight Terminated Conductor.* **J. A. Pollock.** (Phil. Mag. 31. pp. 96–99, Feb., 1916.)—To a first approximation, Abraham and others conclude from theoretical considerations that the wave-length of the disturbance in free ether due to the gravest electrical vibration on a thin straight terminated conductor is equal to twice the length of the rod. This result is very definitely supported by Rayleigh in opposition to the calculation of Macdonald, which makes the wave-length 2·58 times the length of the conductor. The experiments here recorded (and carried out by E. H. Booth and H. P. Tiddy and by R. C. Anderson and J. H. A. Scarr) completely support Rayleigh's view of the value of the wave-length of the vibration on a thin straight terminated rod, and at least imply the experimental verification of his contention "that the difference between the half wave-length of the gravest vibration and the length (*l*) of the rod of uniform section tends to vanish relatively when the section is reduced without limit." E. H. B.

**369.** *Velocities of Electrons emitted in the Normal and Selective Photoelectric Effects.* **A. L. Hughes.** (Phil. Mag. 31. pp. 100–107, Feb., 1916.)—An experimental research from which the following conclusions are drawn :—Although the number of the photoelectrons emitted in the selective photoelectric effect of the sodium-potassium alloy used in these experiments is 26 times as great as the number emitted in the normal photoelectric effect, yet the way in which the two sets of electrons are emitted differs only to a small extent. This small difference may arise either from a somewhat smaller average velocity of the photo-electrons emitted in the selective effect, or else from a greater proportion of the selective photo-electrons being emitted in directions closer to the normal to the surface. These results on the velocities of the photo-electrons in the selective and normal effects are hardly to be expected, if one concludes that the great difference in the magnitude of the two effects, and also their relation to the frequency of the light used, indicates a fundamental difference between the two effects. [See Abs. 1784 (1909) and 842 (1910).] E. H. B.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**370.** *Primary Mercurial Resistance Standards.* **F. A. Wolff, M. P. Shoemaker,** and **C. A. Briggs.** (Bureau of Standards, Bull. 12. pp. 375–464, 1915.)—Describes the construction of 4 mercury units of resistance at the Bureau of Standards, Washington. A number of tubes of Jena glass were procured and 4 others of "Verre dur," but the latter have not yet been used, although their calibre factors are somewhat less than those of the Jena tubes. The respective lengths, calibre factors, and masses of mercury contained by the tubes at 0° C. are as follows :—

| Tube No. | Length. | Calibre Factor. | Mass of Mercury at 0° C. |
|---|---|---|---|
| 1 | 95·08231 cm. | 1·00008925 | 11·57474 gm. |
| 2 | 96·26059 „ | 1·00006593 | 11·86396 „ |
| 3 | 96·99628 „ | 1·00004673 | 12·04271 „ |
| 4 | 100·69377 „ | 1·00009587 | 12·97495 „ |

The calculated resistances in int. ohms at 0° C. of the respective mercury columns, together with the spherical terminal connections, are (1) 0·9999586,

(2) 0·9998815, (3) 1·0001277, and (4) 1·0004287. For the electrical comparisons of the ohm tubes with auxiliary wire standards a modification of the Kelvin double bridge was used. In 1911 a max. difference of 13 parts in 1,000,000 was observed between the resistance units as obtained from the 4 tubes. In 1913 the corresponding difference was 18 parts in 1,000,000. A comparison of the mercury-resistance units of various national laboratories was made in 1913 by means of measurements upon a number of manganin coils sent by the National Physical Laboratory (Teddington) to France, Germany, Russia, and the United States. Mercury resistances have also been set up in the Electrochemical Laboratory at Tōkyō, Japan, and compared with mercury resistances supplied by the National Physical Laboratory. A comparison of the resistance units is given in the following table :—

| Country. | Mercury Unit of Country minus Mercury Unit of U.S.A. |
|---|---|
| England ............................ | + 10 × $10^{-6}$ ohm |
| Germany ............................ | + 28 ,, ,, |
| Japan................................ | + 6 ,, ,, |
| Russia ............................. | + 5 ,, ,, |
| United States of America...... | 0 ,, ,, |

New tubes have been set up in France, but the results are not yet available.

F. E. S.

**371.** *Effect of Temperature on Absorbed Charge and Capacity of Condensers.* **A. Zeleny.** (Phys. Rev. 6. pp. 478–489, Dec., 1915.)—An account of experiments made on condensers of 0·01 to 0·05 mfd. with paraffin-paper, ozokerite-paper, and air-mica dielectrics at temperatures of from — 70° to + 80° C. The measurements were made by the ballistic galvanometer, the discharge periods being timed by means of a pendulum. The effect of moisture in the dielectric upon the temperature variation was also studied. Above a certain narrow range of temperature the absorbed charge shows a marked increase with the temperature. An increase in moisture produces a great increase in the absorbed charge at the higher temperatures but very little at low temperatures. The greater the amount of moisture, the lower the temperature at which the marked increase in the absorbed charge occurs. In condensers in which the absorbed charge is largely due to moisture there is no sudden change near the freezing-point. A mica condenser may have a larger absorbed charge than a paper condenser. Moisture apparently increases the free charge capacity as well as the absorbed charge. The free charge capacity shows a marked increase or decrease with the temperature above a certain range, but this effect does not occur at the same temperature as for the absorbed charge. The free charge capacity of clamped condensers showed a negative, and that of unclamped condensers a positive, temperature coefficient.

W. H. G.

**372.** *Measurement of Small Capacities.* **W. C. Baker.** (Phys. Rev. 7. pp. 112–118, Jan., 1916.)—Discusses an electrostatic method of measuring small capacities, such as those of a ball of 1 cm. radius.

E. H. B.

**373.** *Electric Action in a Liquid Cell bounded by Insulating Walls.* **L. Malclès.** (Comptes Rendus, 161, pp. 694–696, Dec. 6, 1915.)—The author has previously shown that a thin layer of insulating liquid, under the prolonged action of an electric field, acquires a superficial distribution very similar to that which is produced in the interior of a conductor. When the liquid is an electrolyte (water) electrostatic equilibrium is attained immediately, but when the liquid is an insulator (vaseline) the final state is reached slowly by means of the residual current. At first the cells were made of ozokerite, which is a good insulator but does not resist the prolonged action of certain liquids. The author now uses shallow cells consisting of two parallel circular discs of fused quartz, separated by a glass ring; the cell cavities are 4 cm. in diam. and 0·7 cm. in depth. This small cell is suitably supported between electrodes and separated from the latter by a distance of about 1 mm. By means of a diaphragm the flux communicated to the electrometer is limited to the central part of the dielectric. When a balance is obtained on the electrometer, with and without a quartz plate between the electrodes, the dielectric constant of the specimen can be determined. No residual effect was observed in the case of fused quartz, but parallel quartz yielded a marked effect. The dielectric constant of a liquid is determined in a similar manner by balancing the cell with and without liquid. Mercury and water yielded no residual effect, but with insulating liquids such as vaseline, turpentine, and petrol, equilibrium is not attained instantaneously owing to the slow recombination of the ions in the layer. The author has previously determined the conductivities of certain insulating liquids from the values of the velocities of recombination, deduced from observations of the current. The use of quartz permits the extension of this method to all liquids. I. W.

**374.** *Experiments with Filaments heated electrically in Volatile Liquids.* **S. W. J. Smith.** (Phys. Soc., Proc. 28. pp. 51–59, Dec., 1915.)—The first of these experiments was due to Addenbrooke who, using a 100-volt lamp filled with paraffin oil (after removing the tip) as a convenient high resistance in a 200-volt circuit, noticed that some of the many bubbles forming on the filament behaved in a curious way. Instead of rising at once to the surface from the point at which they formed they ran down the legs of the filament, against gravity, and then escaped at the leading-in wires. The present author, led to repeat this experiment, discovered another, more striking, phenomenon. Placing the 100-volt lamp in a 100-volt circuit in series with a variable resistance (water-trough) it was found possible, by momentarily cutting out most of the resistance, to obtain a single bubble upon the wire. The behaviour of such a bubble is very interesting to watch. Instead of escaping at either terminal, as in Addenbrooke's experiment, it travels backwards and forwards between the two, "looping the loops" of the filament in a fascinating way during every journey. The peculiarities of this phenomenon, which can be obtained with either direct or alternating supply, have been analysed by examining the size and motion of the bubble under various conditions and also by using filaments of different materials and liquids of different boiling-points.

It was shown from the experiments that a rapid fall of temperature from the wire through the liquid in the region through which the bubble moves, is an essential condition of the phenomenon, and also, from theoretical considerations, how this condition can be used to explain why the bubble moves in the manner described. AUTHOR.

**375.** *Einstein's Photoelectric Equation and Contact E.M.F.* **R. A. Millikan.** (Phys. Rev. 7. pp. 18–32, Jan., 1916.)—Einstein's photoelectric equation for the max. energy of emission of a negative electron under the influence of ultra-violet light is expressed as follows: $\frac{1}{2}mv^2 = Ve = h\nu - p$. Although the author considers this equation to have no satisfactory theoretical foundation, he has, after searching experimental tests, arrived at the conclusion that it actually represents very accurately the behaviour, as to both photoelectric and contact e.m.f. relations, of all the substances which he has examined. The tests to which Einstein's equation has been subjected to for experimental verification are as follows:—(1) The existence of a definite and exactly determinable max. energy of emission of corpuscles under the influence of a given wave-length. (2) The existence of a linear relationship between photo-potentials and the frequency of the incident light. (3) The exact appearance of Planck's "$h$" on the slope of the potential-frequency line. The photoelectric method is one of the most accurate available methods for fixing this constant. (4) The agreement of the long wave-length limit with the intercept of the potential-frequency line, when the latter has been displaced by the amount of the contact e.m.f. (5) Contact e.m.f.'s are accurately given by the relation $(h/e)(\nu_0 - \nu_0') = (V_0 - V_0')$. (6) Contact e.m.f.'s are independent of temperature. This last result follows from Einstein's equation taken in conjunction with the experimentally well-established fact of the independence of photo-potentials on temperature. If the surface changes in the heating so as to change the photoelectric currents, the contact e.m.f.'s should change also. A. B. W.

376. *New X-ray Tube for Spectroscopic Work.* **M. Siegbahn.** (Deutsch. Phys. Gesell., Verh. 17. 24. pp. 469–470, Dec. 30, 1915.)—A description is given of a metal X-ray tube, the anode of which is insulated by a porcelain sheath. A peculiar cooling device is attached, and the antikathode (fixed directly on the end of the tube facing the anode) that is generally used with the tube, consists of a piece of silver-foil 0·15 mm. in thickness. This tube is particularly useful in the study of soft X-radiations, as well as in X-ray spectroscopy. A. B. W.

## ALTERNATING CURRENTS AND MAGNETISM.

377. *Subsidence of Torsional Oscillations and Fatigue of Iron Wires in Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 15. 1. pp. 1–12, Jan., 1916.)—The series of experiments previously described [see Abs. 220 (1915), 801 (1915)] were continued and extended, and in the present paper an account is given of the results on fatigue and on torsional subsidence which were obtained with iron wires, alternating magnetic fields of frequencies up to 250 per sec. being employed. The apparatus and general methods of experiment were the same as in the earlier experiments. As with nickel wires, the iron wires were subjected in nearly all cases to the same longitudinal load, viz. $1{\cdot}5 \times 10^3$ gm. per cm.$^2$. In the case of Ni wire it was found that the time taken to attain the max. fatigue is inversely proportional to the frequency of the applied alternating magnetic field. In the case of iron the value of the max. fatigue is the same for all the frequencies, whereas for Ni the value of the max. fatigue increases with the frequency up to a certain value of the frequency. The wires were tested whilst in five different states of rigidity; the fatigue of the wire was also tested when in various states of hardness. As the simple rigidity of the wire decreases the damping or subsidence of the torsional oscillations increases roughly as a

straight line law; increasing the frequency of the alternating magnetic field to five times has very little effect on the damping of the oscillations in each state of hardness. The effect of change of load was examined, and it was found that the damping of the oscillations is increased slightly by an increase in the load. Both hard and soft wires were tested. A soft wire with a small load seems to behave in the same way as a hard wire with all loads. Details of the results obtained are given in tables and curves. J. J. S.

**378.** *Thermomagnetic Properties of Various Compounds and the Weiss Theory of Magnetons.* **K. Honda** and **T. Ishiwara.** (Tôhoku Univ., Sci. Reports, 4. 3. pp. 215–260, 1915.)—The results are given of measurements of the susceptibilities of 29 compounds of Fe, Ni, Co, Cr, Cu, Mn, etc., the following general conclusions being drawn:—The susceptibility of paramagnetic compounds has generally a special value different from that derived from the susceptibilities of the constituents by the additive law. Curie's law for paramagnetic substances is applicable to only a very limited number of compounds. For a large number of paramagnetic substances, the hyperbolic law as given by Onnes and Perrier holds good, at least approximately, over the whole temperature-interval in which the substance exists in a single phase. Any abrupt change of susceptibility at a definite temperature or a gradual change from the hyperbolic law over a certain range of temperature is in many cases a consequence of some physical or chemical change. In the diamagnetic substances which have been investigated, the susceptibility is the same for all temperatures so long as the substance exists in the same phase; change of state is accompanied by change in susceptibility. Water of crystallisation diminishes the susceptibility by different amounts for different compounds, and even with the same substance the portions of the water of crystallisation escaping at different temperatures have different effects on the susceptibility. Thermomagnetic investigation affords a good means of detecting changes in the structure of compounds at high temperatures.

The Weiss magneton theory is discussed, and it is concluded that the evidence given by Weiss is insufficient and requires experimental support. The magnetic moments of molecules are also considered. T. H. P.

**379.** *Magnetism and van der Waals' Equation of State.* **J. R. Ashworth.** (Phil. Mag. 30. pp. 711–728, Nov., 1915.)—Curie's paper on the magnetic properties of substances ["Œuvres," p. 330, and Phys. Soc. Abs. No. 598 (1896)] led to conclusions expressible by the equation $H/I = R'T$ for regarding the behaviour of paramagnetic and feebly magnetic substances; where I is the intensity of magnetisation, calculated, as magnetic moment per unit of volume, H the strength of the field, T the absolute temperature, and R′ a constant equal to the reciprocal of Curie's constant A. This equation is obviously a direct analogue of the gas equation, $P/\rho = RT$. Moreover, Curie found that ferromagnetic substances are transformed progressively when heated, and tend to assume the properties of feebly magnetic substances as the temperature increases beyond the point of transformation; he also found a close analogy to exist between the curves $I = f(T)$, for H constant, and $\rho = f(T)$, for P constant, leading to the suggestion that there are critical constants for magnetism as for fluidity, and that the change of state in each at the critical temperature may arise from similar causes. Van der Waals' equation may be written $(\rho + \pi)(\rho^{-1} - \rho_0^{-1}) = RT$, where $\rho$ is the density, treated as the reciprocal of the volume, $\rho_0$ the limiting density, and

$\pi$ the intrinsic pressure, which van der Waals makes of the form $a\rho^2$, where $a$ is a constant. The corresponding equation of a ferromagnetic would be $(H + a'I^2)(I^{-1} - I_0^{-1}) = R'T$, where $a'$, $I_0$, $R'$ are fundamental magnetic constants corresponding to $a$, $\rho_0$, R in the equation of a fluid. The author finds that this represents the chief features of loss of ferromagnetism, viz. (1) a region of increasingly rapid loss up to a critical temperature; (2) an abrupt transition through a region of instability; (3) a region in which I decreases at a decreasing rate and approaches the temperature axis asymptotically. The high value required for the intrinsic or molecular field within a magnet presents a difficulty, but the author points out that the results of his hypothesis are not in conflict with the kinetic theories of Weiss and Langevin. The values of the fundamental constants, critical temperatures, and intrinsic magnetic fields for the ferromagnetic elements are given in the accompanying table.

| | Symbol. | Iron. | Nickel. | Cobalt. |
|---|---|---|---|---|
| Curie's constant ............ | A | 0·281 | 0·048 | 0·166 |
| Paramagnetic constant ... | $1/A = R'$ | 3·56 | 20·8 | 6·0 |
| Max. intensity ............... | $I_0$ | 1685 | 510 | 1300 |
| Intrinsic field constant ... | $a'$ | 7·6 | 92 | 21 |
| Critical temperature ...... | $T_c$ | 785° + 273° | 388° + 273° | 1075° + 273° |
| Max. intrinsic field......... | $a'I_0^2$ | $2·2 \times 10^7$ | $2·4 \times 10^7$ | $3·6 \times 10^7$ |

G. W. de T.

380. *Solar Radiation and Terrestrial Magnetism.* **L. A. Bauer.** (Terrest. Magn. 20. pp. 143–158, Dec., 1915. Summary of two papers read before the joint meeting of the Am. Assoc. for Adv. of Science and the Am. Phys. Soc., Aug. 5, 1915, and the Nat. Acad. of Sciences, Nov. 17, 1915.)—Comparisons have been made between the records of magnetic variations and those of the solar constant as determined by the Smithsonian observers, resulting in an appreciable degree of association between the two phenomena. Decreased solar constant seems to be accompanied by increased magnetic constant, and decreased diurnal range of the earth's magnetism; a change of 1 % in solar constant corresponds to about 0·002 % change in the magnetic constant, and about 1 % change in the magnetic diurnal range. The magnetic effects observed during solar eclipses would correspond to a 10 % change in the intensity of solar radiation. Since the changes in solar radiation are aperiodic, occurring more or less spontaneously, the effect on the earth's magnetism is generally of three-fold character: (*a*) Alteration of diurnal range; (*b*) perturbations of world-wide and local types; (*c*) an outstanding residual effect such as to alter the daily mean value of the magnetic elements by an amount 10 or 100 times that caused by the regularly-progressing secular variation. Comparisons have also been made for sequences of quiet days, and quiet with disturbed days. In general the disturbed days are far more numerous than the quiet days, and this correspondingly affects the value of the resultant secular change, and annual changes of solar constant are found to vary with annual changes of magnetic phenomena. C. P. B.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

381. *Energy-changes in Atomic Formation.* **W. D. Harkins** and **E. D. Wilson.** (Phil. Mag. 30. pp. 723–734, Nov., 1915.)—Nicholson's view of the positive electron does not account for either the close approximation of the atomic weights of the elements to integers or the evolution in radio-active transformations of He only and not hydrogen. The authors therefore prefer Rutherford's view that the hydrogen nucleus is the positive electron, and they have recently shown that both of these facts can then be accounted for [Abs. 127 (1916)]. Assuming mass entirely electromagnetic, the mass will be a function of the energy, and any change of energy will change the mass, and on the basis of the relativity theory Einstein has shown that the relation reduces to the simple form $M = E/c^2$, where $c$ is the velocity of light. On this basis the energy involved in forming a molecule of He is found to have the enormous value $-6{\cdot}708 \times 10^{11}$ cals., which is well in accord with the known stability of He. And it is so much greater than that of the system 4H, *i.e.* the energy of He is so much less than that of 4H that if the atom were about to break up it would be much more unstable with respect to a He disintegration than with respect to the hydrogen disintegration. Egerton in a recent paper [Abs. 589 (1915)] considers the change from 4H to He by this method, but by an error in his calculation obtains the obviously incorrect result that energy must be put into 4H to convert into He, with a decrease in mass, and argues therefore that He found in vacuum tubes can be formed from hydrogen. The authors explain the observed non-formation of He from ordinary hydrogen as being due to the slow reaction velocity, and consider that the evidence of stellar phenomena suggests that part at least of the He which appears in vacuum tubes may be formed from hydrogen. These changes in mass are far too small to be detected; *e.g.* in the formation of a molecule of water 68,000 cals. are liberated, causing a change of mass $= -3{\cdot}18 \times 10^{-9}$ gm. only. G. W. de T.

382. *Changes of Volume of Amalgams.* III. **J. Würschmidt.** (Deutsch. Phys. Gesell., Verh. 16. 16. pp. 799–812, Aug. 30, 1914.)—The explanation of the irregularities met with in the case of the Bi amalgams [Abs. 263 (1914)], is to be found in the assumption that Bi occurs in two modifications, the transition-point of which lies at 75°. This transition of the form $\beta$, stable below 75°, into the other form, $\alpha$, takes place with marked contraction, similar to the transition of solid Bi into the liquid state. On repeated heating and cooling, Bi amalgam loses the property of undergoing transformation, and at the same time a refining becomes evident from the displacement of the contraction corresponding to the melting-point. By very strong heating this phenomenon of refining can again be done away with, and the amalgam recovers the property of passing into the $\beta$-modification at 75°. The assumption of a transition from the $\beta$ to $\alpha$ form on heating above 75°, is in harmony with the observations of E. Wiedemann on Rose's and Lipowitz's metal. A. F.

383. *Practical Substitutes for Platinum and its Alloys.* **F. A. Fahrenwald.** (Am. Inst. Mining Eng., Bull. No. 109. pp. 103–149, Jan., 1916.)—The object of the investigations here described was to find a substitute in dentistry for Pt and Pt-Ir. Such substitute should: (1) be of high melting-point, at least well above 1200°; (2) not be affected by chemical compounds formed in its application, or oxidise at a soldering temperature; (3) possess sufficient strength to resist stresses tending to change its form while in place and at

the same time be sufficiently pliable to be worked to the desired shape; (4) have a low coefficient of expansion, in order that desired dimensions may be easily produced in the finished product; (5) unite readily with gold, silver, and similar metals and their solders; (6) have a low cost of production compared with Pt.

The results of a large number of experiments lead to the conclusion that metals or metallic alloys outside of the precious-metal groups are unsuitable as substitutes for Pt. The Au and Ag alloys of Pd are found to serve as excellent substitutes for Pt in its softer forms and, while not so resistant chemically, answer all requirements where conditions are not too rigid. Excepting for two defects, pure ductile tungsten and, to a lesser degree, Mo meet all the specifications of a practical substitute for Pt and its alloys. These defects, which are ease of oxidation and difficulty of soldering, have been overcome by coating with a precious metal or alloy, the resultant material being in many ways far superior to Pt or its alloys. This material has met with instant demand, is in many cases replacing the best Pt-Ir alloys, and permits of the performance of work hitherto impossible. The theoretical and practical considerations involved in the manufacture of wrought tungsten and molybdenum are discussed. These metals and also W-Mo alloys were produced in the wrought form on a laboratory scale but attempts to produce alloys of tungsten with Au and Pd failed. T. H. P.

384. *Alloys of Tellurium with Lead.* **M. Kimura.** (Kyōtō Coll. Sci., Mem. 1. pp. 149–152, May, 1915.)—The melting-point diagram shows that these elements form only one compound, PbTe, melting at 904°. No series of mixed crystals is formed, but there are two eutectics, one crystallising at 412° and the other being virtually pure lead. Reproductions of photomicrographs are given. T. H. P.

385. *Metallographic Investigation of the System, Tellurium-Selenium.* **Y. Kimata.** (Kyōtō Coll. Sci., Mem. 1. pp. 119–121, May, 1915.)—Investigation of the melting-point diagram shows that tellurium and selenium form two uninterrupted series of mixed crystals, and micrographic examination of sections shows that these are homogeneous at all concentrations. At the concentration 95 % Se and at 180° the crystals have the same composition as the fusion. T. H. P.

386. *Metallographic Investigation of the System, Antimony-Tellurium.* **Y. Kimata.** (Kyōtō Coll. Sci., Mem. 1. pp. 115–118, May, 1915.)—The results of earlier investigators indicate with certainty the existence of the compound $Sb_2Te_3$ but leave undecided the question of the existence of SbTe and of the formation of mixed crystals between $Sb_2Te_3$ and Sb in the solid state. The author has traced the diagram of state and made a micrographic investigation of this system and finds that the only compound formed is $Sb_2Te_3$, which melts at about 620° and forms eutectics with both Sb and Te. T. H. P.

387. *On a supposed Allotropy of Copper.* **G. K. Burgess** and **I. N. Kellberg.** (Washington Acad. Sci., J. 5. pp. 657–662, Dec. 19, 1915.)—The authors have carried out a series of determinations of the electrical resistance of copper between 0° and 100° C., and the results show that between this interval of temperature the resistance varies continuously. They conclude, therefore, that the allotropic transformation of copper at about 70° C. described by Cohen and Heldermann [Abs. 986 (1914)] does not exist.

F. C. A. H. L.

388. *Metallic Crystal Twinning by Direct Mechanical Strain.* **C. A. Edwards.** (Inst. of Metals, J. 14. pp. 116–130; Disc., 131–144, 1915. Engineering, 100. pp. 407–409, Oct. 15, 1915.)—In order to settle the much-discussed question as to whether the twinning in metals can be brought about by simple strain, the author has made numerous examinations of specimens of tin and zinc which has been cast between two pieces of highly polished and heated steel. If the mass were agitated during solidification twin crystals were often present, and such specimens were always discarded. Mechanical straining was effected by scratching with a needle or by a sharp blow with a light hammer. It was found that when the surface for examination was bent in compression twin markings were always formed, but when bent in tension similar markings were seldom produced on the surface. The specimens were examined in the following conditions: immediately after casting, after straining, and after polishing and etching subsequent to straining. The author considers that all the available evidence indicates that twin crystals are produced in tin as the direct result of mechanical strain. The view of spontaneous annealing is not permissible, because it was found that when tin was strained at 100° C. practically no twins were formed, but at temperatures much below 0° C. twins were formed in large numbers. The mechanism of twinning, and its effect on the theory of hardening, is discussed at some length. F. C. A. H. L.

389. *Effect of Carbon on the Physical Properties of Carbon Steels in Various Conditions of Heat-treatment.* **J. H. Nead.** (Am. Inst. Mining Eng., Bull. No. 108. pp. 2341–2357, Dec., 1915.)—Static tensile tests, ball-hardness tests, and a micrographic examination have been made on a series of carbon steels containing from 0·14 to 1·46 % carbon. Each steel was tested in the hot-rolled, annealed, water-quenched and oil-quenched states, and also after oil-quenching followed by tempering at various temperatures. The temperatures chosen for annealing and quenching were based on the annealing temperatures for carbon steels recommended by the American Society for Testing Materials (Year Book, 1914, p. 201). The results obtained are summed up in 9 tables and 11 diagrams. In a general way they indicate that in annealed steels the max. yield-point and max. strength are obtained in the steel of eutectoid composition. Up to this composition, increase of carbon rapidly increases the strength. In the heat-treated steels the ultimate strength does not show any falling off until a content of 1·2 % carbon is reached. The elongation and contraction show increasing values with decrease of carbon-content. The paper is illustrated by 24 micrographs, and it is intended to extend the work to a determination of the shock-resisting properties of the steels as measured by the Charpy impact bending test. F. C. A. H. L.

390. *Alloy Steel of Special Composition.* **J. B. Rhodes.** (Am. Soc. Naval Eng., J. 1915. Mech. Eng. 38. p. 61, Jan. 28, 1916. Abstract.)—Describes the qualities of an alloy steel which has been found to furnish high-grade castings and forgings from the same mix and at comparatively low cost. In order to obtain the desired results, the carbon was limited to 0·35 % and the Mn to 1·2; Ni was added in the form of nickel Ni-steel turnings and Ni with Cu in the form of monel-metal scrap. The composition aimed at is as follows: Carbon 0·3 to 0·35, silicon 0·25 to 0·35, phosphorus and sulphur not over 0·05, manganese 1·0 to 1·2, nickel 1·5 to 1·8, copper 0·5 to 0·8 %. The addition of Cr in sufficient quantity to give 0·5 % Cr is said to increase the physical properties to those of ordinary Cr-Ni steels containing 1·0 % Cr and 3 % Ni. C. O. B.

**391.** *Cause and Effect of "Ghost Lines" in Large Steel Forgings.* **J. O. Arnold.** (Inst. Mech. Eng., J. 9. pp. 653–666; Disc., 667–672, Dec., 1915, and pp. 675–699, Jan., 1916. Engineering, 100. pp. 542–544, Nov. 26, 1915. Mech. Eng. 36. pp. 485–488, Dec. 3, 1915. Abstract.)—Comparison of the compositions of shavings from the ghost-free portions and the ghost lines of a large mild-steel ingot gave the following figures:—

| | Ghost-free Portions. | Ghost. |
|---|---|---|
| Carbon, % | 0·320 | 0·380 |
| Silicon, % | 0·080 | 0·310 |
| Manganese, % | 0·680 | 0·920 |
| Sulphur, % | 0·020 | 0·045 |
| Phosphorus, % | 0·035 | 0·050 |

Microscopic examination of the ghosts showed the presence of excess of MnS and also excess carbon in the form of troostitic pearlite, together with silicate of manganese. It is obvious that the elements responsible for the segregation are carbon, sulphur, and phosphorus. Immediately after solidification and after forging the ghost lines are highly carburised, but after annealing, the ghosts become decarburised owing to the dissolved phosphide expelling the carbide to the edges of the ghost. Mechanical tests—tension, torsion, and alternate bending—show that the material containing ghosts is not materially different from ghost-free material so long as the plane of the stress is at right angles to the ghost lines. Examination of ghosts expelled from a Cr-Ni steel ingot which had burst during the casting showed that they consisted of compound and variable segregates of C, S, P, and Ni. It appears that the Ni up to about 5 % is not associated with the carbon, but forms a nickelide of iron, $Fe_7Ni_4$. In the rolled state this alloy has a yield-point of nearly 60 tons per sq. in., an ultimate stress of 90 tons per sq. in., with an elongation of 11 % in 2 in., and a contraction of 46 %. Contrary to the general belief that the ghosts are the traces of the last-solidifying portions of the metal, the author considers that the results of his researches prove conclusively that they solidify first. In the process of solidification of an ingot the first portion to freeze is a definite compound or solution of iron and sulphide of manganese. Being of relatively low density the material rises through the main mass of the steel, and in so doing forms nuclei to which the migratory constituents attach themselves. F. C. A. H. L.

**392.** *Corrosion of Iron.* **K. P. Grigorowitch.** (Rev. Soc. russe de Metall. 1. pp. 70–88, and 115–147, 1914. Rev. de Mét. 12E. pp. 242–247, July, 1915.)—Of the three different theories regarding the cause of the rusting of iron, namely, (1) based on the action of carbonic acid, (2) based on the formation of hydrogen peroxide, and (3) based on the theory of electrolytic action, the author gives preference to the latter. Study of the effect of contact with metals whose potential is lower than that of iron, such as Pt, Cu, Ni, Pb, and Sn, shows that these materials increase the rate of corrosion, Pt producing the greatest, and Sn and Pb exercising the least, effect. Contact with metals like Mg, Zn, and Mn, whose potential is greater than that of iron, retards the formation of rust. The effects of Cu and Zn make themselves apparent for some distance from the point of contact. The author has also studied the effect of ferrous sulphide on corrosion. This material favours the formation of rust, and is not dissolved itself by corrosion in water. The electrolytic potential of sulphides is less than that of iron, and the acute corrosion of iron containing sulphur is explained by the formation of galvanic couples between MnS and ferrite, resulting in the rapid solution of the latter. This contradicts the theory put forward by Friend, Bentley, and West, to the effect that the corrosion of steels containing sulphur is accelerated by the oxidation of the sulphur to sulphuric acid. Comparison of the relative rates of corrosion of cast iron, wrought iron, and steel has shown that in tests of short duration the cast iron is dissolved more rapidly than iron or steel. The rate of corrosion of cast iron, however, diminishes in time, so that in prolonged tests there does not appear to be much difference between the three classes of materials. The corrosion of iron proceeds in two stages: (1) dissolution according to the equation $Fe + 2H = Fe'' + H_2$, and (2) oxidation of the ferrous to ferric oxide. Assuming that the first stage takes place in the absence of air, the conversion of metallic iron into ions can only take place if the iron has a potential greater than that of hydrogen. The value of the two potentials varies according to the degree of dissociation of the water. When the concentration $m'$ of the iron in aqueous solution is less than the concentration $m_1$ of the ions, dissolution continues, and the new ions precipitate $Fe(OH)_2$ from solution. In this case the loss in weight indicates the solubility according to the first stage of the corrosion. But if the concentration of the iron is greater than the ionic concentration at saturation, dissolution ceases before ionic saturation is attained. Reaction (1) now becomes subservient to stage (2), and hence the loss in weight becomes a measure of the oxidation. The addition of acid increases the ionic concentration and restores the first state of affairs in which $m' < m_1$. Experiments to determine the effect of heat treatment on the solubility in 1 % sulphuric acid, have been carried out on carbon, nickel, chrome, and chrome-nickel steels. The results show that the carbon content has little effect on the solubility of a steel. Max. solubility is attained in quenched steels subsequently tempered between 0° and 400° C. In the majority of cases annealed steel has the least solubility. The solubility-tempering curves show a rapid fall in the solubility at temperatures about 400° C. for all classes of steels. Experiments on the potential of heat-treated steels showed that while heat treatment undoubtedly affects the potential developed in a galvanic cell, the effect is characterised not so much by the initial and final values of the e.m.f. as by the shape of the e.m.f.-time curve. The methods of protection of iron against rusting are considered and a bibliography of the literature of the corrosion of iron is appended.

F. C. A. H. L.

393. *Determination of Grain-size in Metals.* **Z. Jeffries, A. H. Kline, and E. B. Zimmer.** (Am. Inst. Mining Eng., Bull. No. 108. pp. 2359–2369, Dec., 1915.)—The properties of a metal vary considerably with the size of its grains. For most industrial purposes a fine-grained structure is desirable, since a fine structure is usually accompanied by high elastic strength. Occasionally, such as in the case of transformer iron, a coarse grain is preferred. It must be distinctly understood that the terms fine and coarse grained are purely relative; for example, fine-grained copper may be coarser than coarse-grained high-speed steel and fine-grained copper may be coarser than coarse-grained wire drawn from steel obtained from the same heat. In metals which have been subjected to the action of high temperatures grain-size is often a better indication of the quality of the metal than the tensile strength is, and in any case the measurement of grain-size is a very valuable adjunct of the tensile test. The planimeter method of measuring

grain-size is accurate but tedious. The Heyn method is most conveniently carried out by projecting an image of the micro-section at known magnification on to a screen of squared paper. By counting the number of grains intersected by each line, the average dimensions of the grains in two directions at right angles to each other are obtained, and the product of these two values divided by the square of the magnification gives the average area of the grains. The intercept method as developed by Howe is similar, except that the measurements are not made along parallel lines. A large number of determinations of the results obtained by these two methods in comparison with the results given by the planimetric method indicate that neither of them is very accurate, the Heyn being subject to an average error of about 13 %, while the intercept method is subject to an error of about 22 %. Accordingly, the authors have developed a new method in which the image is projected on to a screen on which is ruled a circle of known dimensions whose area is less than the total area of the image. The number of complete and incomplete grains lying inside the circle are counted separately, and the incomplete grains are converted into the equivalent number of complete grains by multiplying by 0·6, a factor which has been determined by a large number of planimetric observations. The largest error found in 187 determinations has been found to be 6·4 %, the average error being only 2·1 %. In the application of any of the above methods it becomes necessary to obtain a fair representation of the sample under examination, and the authors have adopted the following general rules for sampling:—(1) Use such a magnification that the field includes at least 50 grains. (2) Make at least five determinations at about equal intervals along a diam. of the specimen and either take the average value or, in cases where one part of the specimen differs considerably from another part as regards grain-size, record and note the position of the limiting values. (3) In the case of such samples as small wire, determine the total number of grains in the cross-section, and also the number for a given length of the longitudinal section. (4) In cold-worked samples, the degree of cold-working can be expressed by the ratio of the length to the width of the grains. The Heyn method can be used most conveniently for determining this ratio. F. C. A. H. L.

394. *Determination, by the Method of Diffusive Convection of the Coefficient of Diffusion of a Salt dissolved in Water.* **A. Griffiths.** (Phys. Soc., Proc. 28. pp. 21-34; Disc., 34, Dec., 1915.)—The object of the research was to develop a method of determining the coefficient of diffusion of a salt dissolved in water which involves the application of purely physical, as distinct from chemical, measurements, which possesses the characteristic that all measurements are made after the attainment of the steady state of diffusion, and which promises to possess the advantage that there shall be no disturbance of the apparatus, internally or externally, during the period of crucial observations. In general the diffusion of matter, like the diffusion of heat, produces convective currents, and there is a diffusive convection which is akin to thermal convection. The theory of the method is first dealt with and the essential features of the apparatus are then described whereby a convective flow is obtained of the order of one-millionth of a cm.$^3$ per sec. from the top of one set of diffusion tubes to the top of another set. The top of each set of diffusion tubes is enclosed in a glass vessel containing water, and the one vessel is connected to the other by means of a long capillary tube. Each set of 8 diffusion tubes is of length about 5 cm., and has a total area of cross-section of about 0·5 cm.$^2$. The capillary tube is about 150 cm. long, and has a

diam. of 1 mm.; the linear flow of a coloured index, consisting of a feeble solution of uranine, is of the order of 10 cm. per day, while the index is introduced by means of a special four-way glass tap. Preliminary work and difficulties encountered are well described, particularly the means taken to remove the remarkable growths which tend to form in the apparatus. Tables of results are given. H. H. Ho.

395. *Determination of the Coefficient of Diffusion of Potassium Chloride by an Analytical Method.* **A. Griffiths, J. M. Dickson, and C. H. Griffiths.** (Phys. Soc., Proc. 28. pp. 78–80; Disc., 80, Dec., 1915.)—An attempt has been made to develop an analytical method of determining the coefficient of diffusion of a salt in water capable of yielding consistent and accurate results. The lower ends of a number of vertical diffusion tubes end in a reservoir of large capacity containing a solution of potassium chloride. The greater part of the reservoir is above the lower ends of the tubes and by gravity the solution at the lower ends is kept at an approximately constant concentration. The upper ends of the tubes are covered with a cap provided with an outlet and an inlet tube. Water enters the cap by the inlet tube, and a weak solution containing the diffused salt leaves the cap by the outlet tube. Time, which may be as long as a fortnight, is allowed for the attainment of the steady state, and an individual experiment may last six weeks. The quantity diffused is obtained by chemical analysis. In the case of a solution containing 0·2287 gm. of KCl to the c.cm. (a 3N-solution), the "mean diffusivity" with respect to water is $1{\cdot}708 \times 10^{-5}$ c.g.s. units at 18·5° C. T. H. P.

396. *Remarks on Osmotic Pressure.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 18. pp. 184–190, Sept. 8, 1915.)—The osmotic pressure deduced thermodynamically is given by the equation—

$$\pi = p - p_0 = RT/v_0 . [-\log. (1-x) + \alpha x^2],$$

where $\alpha$ is the so-called "influencing" coefficient in consequence of the *interaction* of the molecules of the solvent and those of the dissolved substance; all kinetic theories of osmotic pressure, which are not in accord with thermodynamics, and which omit the logarithmic term for concentrated solutions are invalid. For very dilute solutions the above equation assumes the familiar form $\pi = RT/v_0 . x$; but the deviations in strong solutions are so much less than in the non-ideal gaseous state, and the logarithmic term persists into such very dilute solutions that there is good reason to think that the comparison with gases is a mere *analogy* rather than a definite *relation*, *i.e.* osmotic pressure is entirely different in its origin from gas pressure.

If the osmotic pressure were caused by the pressure of the dissolved substance, as van't Hoff and others have assumed, the pressure of the "sugar" molecules against the semi-permeable membrane would cause the reverse of what is actually observed, *i.e.* no water would be drawn into the osmometer, but all flow would be checked because there was already a greater pressure inside. In reality osmotic pressure is caused *by the water* penetrating through the semi-permeable membrane into the sugar solution, and giving rise to a hydrostatic pressure; this excess of pressure, $\pi = p - p_0$, is the so-called "osmotic pressure" of the solution. A kinetic theory of osmotic pressure can only be sound if based upon a study of the *diffusion* of the water-molecules, which is the origin of all the phenomena. T. M. L.

397. *The Conduction of Electric Current in Ethyl Ether.* **J. Fassbinder.** (Ann. d. Physik, 48. 4. pp. 449–480, Nov. 9, 1915. Dissertation, Greifswald.)—The author finds the following results;—The dissociation of pure ether is

exceedingly small, and the conductivities hitherto observed are to be attributed to impurities. These impurities do not, however, exist in an ionised condition in the ether, but are adsorbed and ionised on the electrodes. These ions are then detached from the electrodes by means of the electric field. Well-dried electrodes of Pt and of Ag behave very differently. Platinum adsorbs the ion-forming substances only feebly and readily gives them up, and consequently the current rapidly falls owing to the loss of ions by the electrodes. Silver, on the other hand, shows a marked adsorptive power for the ion-forming substances, and also retains the ions rather firmly on its surface. On passing the current, therefore, between silver ions, there is only a slight fall in conductivity. In one case, with a rather impure specimen of ether, the existence of ions in the liquid was also detected, but the measurements lead to the conclusion that the dissociating substance is mainly driven out of the electrodes by the electric field. A. F.

**398.** *Alumina in Steel.* **G. F. Comstock.** (Met. and Chem. Eng. 13. pp. 891–895, Dec. 1, 1915.)—Sulphides form the most common inclusions in commercial steels. They were formerly thought to consist of manganese sulphide, but recent investigations have shown that they contain varying proportions of iron sulphide. Next in importance are the silicates or true slag inclusions. Recently evidence has been collected which permits of the differentiation between slag inclusions, alumina, and titanium nitride. The latter substance is readily distinguished by its pink colour. Alumina forms small rounded spots which are very dark in colour and differ from true slag inclusions in the following particulars:—Slag inclusions generally take a fairly smooth polish, while alumina is very hard to polish without either scratching or pitting. While slag inclusions are always elongated in the direction of rolling or forging, individual particles of alumina are never elongated, although the groups of particlesmay be elongated. Silicate inclusions of large size are frequently met with in steel, but the particles of alumina appear to be incapable of coalescence even when they are grouped very close together.

Sixteen micrographs are reproduced to illustrate the differences between sulphides, slag, titanium nitride, alumina, and oxides of chromium, titanium and nickel. F. C. A. H. L.

**399.** *Chemical and Mechanical Relations of Iron, Molybdenum, and Carbon.* **J. O. Arnold** and **A. A. Read.** (Inst. Mech. Eng., J. 9. pp. 629–651, Dec., 1915. Engineering, 100. pp. 555–557, Nov. 26, 1915.)—Contains the results of an examination of a series of five Mo steels containing from 2·48 to 20·7 % Mo and about 0·8 % C. The results of mechanical tests are given. An examination of the carbides separated by an electrolytic method gave interesting results. These show that at about 18·25 % Mo free carbide of iron disappears and a double carbide of Fe and Mo obtains, which corresponds to the formula $Fe_3Mo_3C$. This ferro-molybdenum carbide is obtained as a fine grey powder, insoluble in strong boiling HCl, and is not attracted by a magnet.

From experiments on drastically hardened bars of the 20·7 % Mo steel, the authors conclude that the carbon in hardened steels exists in the form of carbide in solid solution.

It is shown that ferro-molybdenum pearlite contains 18·25 Mo and 0·71 % C, and that its transformation into hardenite seems to begin somewhere upwards of 900° and is about completed at 1100° C.

The paper contains a general survey of the constitution of carbon, vanadium, tungsten, and ferro-molybdenum steels, together with points of resemblance and of difference between the actions of W and Mo on steel.

C. O. B.

**400.** *Addendum on Alloys of Iron and Molybdenum.* **R. A. Hadfield.** (Inst. Mech. Eng., J. No. 1. pp. 701–713, Jan., 1916.)—Contains the results of a series of tests carried out some eight years ago on Mo-Fe alloys. In one series the Mo was added as ferro-molybdenum, and in a second series the Mo was added as metal; this series gave the more uniform results. These results show that the effect of Mo *per se* upon iron and without the presence of other elements is not likely to be of importance; the alloys containing up to 3 % Mo show little variation in properties. The alloys containing more than 7 % Mo show a considerable increase in hardness, in spite of the low carbon present. A useful bibliography is included in the paper. C. O. B.

**401.** *Influence of Oxygen on Some Properties of Pure Iron.* **W. Austin.** (Iron and Steel Inst., J. 92. pp. 157–161; Corres., 162–163, 1915. Engineering, 100. pp. 455–456, Oct. 29, 1915.)—Highly oxygenated alloys, containing about 0·24 % oxygen, were prepared by melting pure iron with ferric oxide, lime, and magnesia in a Girod electric furnace. Cooling curves show that the presence of the oxide has no appreciable effect on the melting-point nor the A*r*2 point, but it does lower the A*r*3 point. Micrographic examination shows the oxide to be present in mechanical admixture, and under high magnifications the inclusions reveal a eutectic structure. It would appear that the oxide is soluble in molten iron, but is rejected on solidification. With regard to corrosion resistance, it appears that the alloys resist atmospheric corrosion very well, but that mild steel gives better results in dilute acids and wrought iron is superior in sea-water. With increasing oxygen, the density decreases and the hardness increases. Impact tests show that the material possesses "blue-brittleness," with subsequent recovery. Rolling difficulties are experienced at 900°, but manipulation can readily be effected at temperatures above 950° C. F. C. A. H. L.

**402.** *Molecular Weights of Gases by an Evaporation Method.* **H. L. Trumbull.** (Am. Chem. Soc., J. 37. pp. 2662–2667, Dec., 1915.)—The following table shows the relative rates of evaporation of water at 25° C. from tiny bottles of 3 c.cm. capacity made from capillary tubing having a bore of 6 mm., 1 mm., and 4 mm., into atmospheres of air, hydrogen, and carbonic anhydride :—

RELATIVE DIFFUSION RATES.

| | $H_2$/Air. | $H_2/CO_2$. | Air/$CO_2$. |
|---|---|---|---|
| Bottle 1 ...................... | 3·40 | 4·77 | 1·40 |
| Bottle 2 ...................... | 3·24 | 4·78 | 1·48 |
| Bottle 3 ...................... | 3·54 | 4·93 | 1·39 |
| Mean ...................... | 3·39 | 4·83 | 1·42 |

The relative rates calculated from Graham's law of diffusion are 3·79, 4·67, 1·24. It therefore appears that the relative rates of evaporation are determined by the rates of diffusion of the gaseous atmosphere, and might be applied in determining the molecular weights of the gases. It is suggested that the explanation of higher and more constant terrestrial temperatures in geologic eras, notably in the carboniferous, may be connected with the slower evaporation of water into an atmosphere rich in $CO_2$. The dependence of rate of evaporation upon the nature of the gas suggests that the feeling of warmth caused by $CO_2$ upon the nerves of the hand may be due to retardation of the normal rate of perspiration. T. M. L.

403. *Influence of Heat-treatment on Specific Resistance and Chemical Constitution of Carbon Steels.* **E. D. Campbell.** (Iron and Steel Inst., J. 92. pp. 164–178; Corres., 178–180, 1915. Engineering, 100. pp. 681–683, Dec. 31, 1915. Electrician, 76. pp. 27–29, Oct. 8, 1915. Abstract.)—The work described in Abs. 1781 (1915) has been extended to a series of iron-carbon alloys containing from 0·04 to 2·71 % carbon. The specific resistance of these alloys has been determined after quenching from 892° and 1103° C. Study of the results shows that the specific resistance of a quenched steel increases with the temperature of quenching, which is compatible with the view that the molecular weight of the dissolved carbides is lowered by progressive dissociation. Another point is the increase of specific resistance of hypoeutectoid steel after heating to 800° as compared with the result of reheating to 600° or 700° C. The results of tempering and the theoretical aspect of the subject have already been discussed [*op. cit.*]. F. C. A. H. L.

404. *Density and Viscosity of Aqueous Solutions, with Special Reference to Nitric Acid. I. Densities.* **W. R. Bousfield.** (Chem. Soc., Trans. 107. pp. 1405–1426, Sept., 1915.)—The densities of aqueous solutions of nitric acid from N to N/32 were determined with very great care at 4°, 11°, 18°, and 25° C. The accidental errors, as shown by the concordance between observed and calculated values did not exceed about ± 0·000005. These observations are interpreted by means of a "*contraction function*" $\chi = V(\rho/\rho_w - 1)$, where V is the volume in c.cm. of a solution containing one equivalent or gm.-molecular weight E of solute mixed with H gm. of water, or, if all densities are relative to water $\chi = 1000\,\Delta\rho/m$: it is thus a function of the same character as the "molecular freezing-point depression" or the "molecular viscosity increment." The contraction which occurs in producing 1 c.cm. of solution is given by $\zeta = (\chi - \chi_0)/(E + H)v$, and it is proposed to describe as the "*euthetic-point*" the composition at which the contraction $\zeta$ is a maximum, so that $d\zeta/dH = 0$. Geometrical relationships between the various quantities are deduced. The euthetic-point for nitric acid is calculated to correspond with $HNO_3, 8H_2O$; for sulphuric acid it is given as 5/8 $H_2O$ instead of $2H_2O$ as given by Mendeleef; for solutions of sucrose the euthetic-point is about 0·1 $H_2O$, and probably depends on changes in the constitution of the solvent, rather than on the formation of a "euthetic hydrate." T. M. L.

405. *Production of Movement by Molecular Directive-force in Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 48. 2. pp. 177–192, Oct. 14, 1915.)—An account is given of various ways in which the directive forces of crystallisation may give rise to actual motion. In the case of liquid-crystals, the motion set up is shown by 12 series of kinematograph pictures, each containing 21 exposures. T. M. L.

406. *On Willard Gibbs' Adsorption Coefficient.* **A. W. Porter.** (Faraday Soc., Trans. 11. pp. 51–52, Oct., 1915.)—Gives an outline of a proof of Gibbs' absorption theorem, which is easily extended to the case of strong solutions. L. H. W.

407. *Simple Method of deriving the Gibbs Absorption Formula.* **F. J. Harlow** and **R. S. Willows.** (Faraday Soc., Trans. 11. pp. 53–54, Oct., 1915.)—The direct method here described of treating such problems makes use of the idea of chemical potential. L. H. W.

408. *Dissolution and Separation of Substances, and especially of Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 47. 6. pp. 832–852, Aug. 17, 1915.)—The existence of liquid-crystals is incompatible with the view adopted by Nernst that in a crystalline solid the molecules are replaced by atoms grouped into space-lattices, since liquid-crystals (which are not sharply separated from solid crystals) do not usually exhibit this complete rectilinear lattice-structure. It is also urged that liquid-crystals are incompatible with various theories of identity, *e.g.* identity of the molecules of liquid and vapour in evaporation or at the critical-point, and of dissolved and gaseous molecules; the view is adopted that, on the contrary, the molecules of an isotropic melt cannot be identical with those of the liquid-crystalline modification, apparently because the unequal solubility or stability of these two forms cannot be attributed to dissimilar physical structure, where both forms are so largely chaotic. Nernst's form of the osmotic theory of solutions ("solution-pressures," etc.), is also regarded as untenable. A modified physical theory is put forward, according to which the separation from solution of liquid or solid bodies brings into consideration the following forces: expansive force, self-purifying force, cohesion or adhesion pressure, and (especially in liquid-crystals) molecular-directive forces which influence all the others. The formation of crystals, especially of mixed crystals, does not depend simply on the predominance of van't Hoff's osmotic pressure over the solution-tension, but is essentially an effect of the same forces which determined adsorption. Crystals grow by the adhesion of ready-formed molecules which are present in the solution, but the molecules of different polymorphic modifications and "states of aggregation" of a substance are not identical. T. M. L.

409. *Calomel Standard Cell.* **G. F. Lipscomb** and **G. A. Hulett.** (Am. Chem. Soc., J. 38. pp. 20–27, Jan., 1916.)—The combination studied is—

$$\text{Cd Amalgam} \mid CdCl_2 . 2\tfrac{1}{2}H_2O . Hg_2Cl_2 \mid Hg,$$

and the results obtained prove a reproducibility and constancy rather better than that of either the Clark or Weston cells. The cadmium chloride was freed from metals having a lower electrolytic potential than Cd, and in addition any of the metals with sulphides more insoluble than that of Cd. The $Hg_2Cl_2$ was prepared electrolytically from mercury and hydrochloric acid, a current density of 2 amps. per 100 cm.$^2$ of electrode surface being used. The product obtained was crystalline and grey in colour, due to the presence of finely-divided mercury. A 10% cadmium amalgam was used in the construction of the cells. Two groups of cells were made at different times, using calomel and cadmium chloride from two different preparations. The cells appear to be reproducible within 0·00001 volt. Finally the various thermodynamic and thermochemical relations in connection with the reaction occurring in the cells are considered. F. E. S.

410. *Double Salts in Standard Cells.* **G. F. Lipscomb** and **G. A. Hulett.** (J. Phys. Chem. 20. pp. 75–82, Jan., 1916.)—Double salts such as $ZnSO_4 . K_2SO_4 . 6H_2O$ and $CdSO_4 . K_2SO_4 . 6H_2O$ may be used in Clark and

Weston standard cells respectively, while double chloride salts such as $ZnCl_2\,2KCl$ also offer some possibilities. Furthermore, with one double salt we may have three different saturated cells, viz.—

$$\text{(1) Zinc Amalgam} \left\{ K_2SO_4 . ZnSO_4 . 6H_2O \right\} Hg_2SO_4 \mid Hg$$

$$\text{(2) Zinc Amalgam} \left\{ \begin{matrix} K_2SO_4 . ZnSO_4 . 6H_2O \\ ZnSO_4 . 7H_2O \end{matrix} \right\} Hg_2SO_4 \mid Hg$$

$$\text{(3) Zinc Amalgam} \left\{ \begin{matrix} K_2SO_4 . ZnSO_4 . 6H_2O \\ K_2SO_4 \end{matrix} \right\} Hg_2SO_4 \mid Hg$$

where the double salt, or double salt and simple salt, with their saturated solutions, represent reproducible equilibrium-points in the phase-rule diagram. The phase relationships of the various salts was fully investigated and the e.m.f.'s of combinations (1), (2), and (3) were determined to be 1·46965, 1·41976, and 1·48680 volts respectively at 25°. Chloride cells were also investigated. F. E. S.

**411.** *Periodic Passivity of Iron.* **A. Smits** and **C. A. L. de Bruyn.** (K. Akad. Amsterdam, Proc. 18. Nos. 4–5. pp. 807–811, 1916.)—The passive state of iron can be abolished by bringing it into contact with solutions containing chloride, bromide, or iodide ions. With an iron anode and a ferrous sulphate electrolyte, therefore, it should follow that at a given velocity of solution of the iron, as determined by the current density, it should be possible to find a concentration of chloride ions (obtained by the addition of ferrous chloride) such that, at a particular instant the chance that the iron remains passive is just as great as the chance that it becomes active, and *vice versa.* If, at this moment, the current density is somewhat diminished, the change from passive to active will take place, with the result that iron goes into solution. The ferrous ions thus produced in the neighbourhood of the anode will decrease the concentration of the chloride ions, with the result that the iron will become passive again after a time. The above process will then be repeated again, with the result that periodic phenomena should be observed.

The authors have been able to verify the above deductions. With a solution containing 0·473 mol. $FeSO_4$ and 0·023 mol. $FeCl_2$ per litre, and a current density varying from 0·155 amp./cm.$^2$ (passive) to 0·195 amp./cm.$^2$ (active) a variation in the anodic potential from $+1·4$ volts to $-0·84$ volt was obtained, the duration of the period being 6·54 secs. and the passive state lasting about as long as the active state. With current densities of 0·180 amp./cm.$^2$ (passive) and 0·255 amp./cm.$^2$ (active), the duration of the period was 5·8 secs., the passive state lasting longer than the active. When iron has been made passive by anodic polarisation in an electrolyte of ferrous sulphate, and the current is then cut off, the anodic potential diminishes rapidly at first, next remains fairly constant for a short time, and afterwards diminishes again rapidly. The constant potential has been explained by Smits and Aten as being due to the existence of passive and active metal side by side, the passive phase gradually changing into the active. Since chloride ions accelerate this change, it should be possible to eliminate this constant potential altogether, by the addition of ferrous chloride. This is found to be the case with a 0·478 molar solution of ferrous sulphate, to which is added 0·00048 mol. of ferrous chloride. Lower concentrations of ferrous chloride simply diminish the time of duration of the constant potential. T. S. P.